THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 52 Thursday, May 30, 1935 No. 980

PUBLISHED WEEKLY.

Subscription Terms: 15s. per annum.
Foreign and Colonial: 17s. 6d. per annum.
All Subscriptions are payable in advance.

All Communications to be addressed to the Editor, the Advertisement Manager, or the Publisher of

THE FOUNDRY TRADE JOURNAL,
49, WELLINGTON STREET, LONDON, W.C.2

Telegraphic Address: "Zacatecas, Rand, London."
Telephone: Temple Bar 3951 (5 lines).

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF

The Institute of British Foundrymen
The Institute of Vitreous Enamellers
The National Ironfounding Employers' Federation
The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

Institute of British Foundrymen

PRESIDENT: 1933-34.

Roy Stubbs, 36, Broadway, Cheadle, Cheshire.

LIST OF SECRETARIES—

General Secretary: T. Makemson, Saint John Street Chambers, Deansgate, Manchester. London Office: 49, Wellington Street, London, W.C.2.
Birmingham, Coventry and West Midlands: A. A. Timmins, A.I.C., 21-23, St. Paul's Square, Birmingham.
Sheffield: T. R. Walker, "The Priory," Oughtibridge, near Sheffield.
Scottish: J. Bell, 60, St. Enoch Square, Glasgow.
Lancashire: J. E. Cooke, 1, Derbyshire Crescent, Stretford, Manchester.
London: H. W. Lockwood, Stewarts and Lloyds, Limited, Winchester House, Old Broad Street, London, E.C.2.
Newcastle-upon-Tyne: W. Scott, Sir W. G. Armstrong, Whitworth & Company (Ironfounders), Limited, Close Works, Gateshead-on-Tyne.
East Midlands: B. Gale, "Oakdene," Greendale Road, Nottingham.
West Riding of Yorkshire: S. W. Wise, 110, Pullan Avenue, Eccleshill, Bradford.
Wales and Monmouth: J. J. McClelland, 122, Wellington Road, Bilston, Staffs.
Middlesbrough: D. Anderson, 147, Stockton Street, Middlesbrough.
Preston: P. Leyland, 6, Ashley Terrace, Farington, Lancs.
Lincoln: E. R. Walter, "Cavalla," Erntwell Road, Lincoln.
Burnley: W. Haworth, 72, Branch Road, Burnley, Lancs.
Falkirk: H. McNair, 14, Seabegs Crescent, Bonnybridge, Scotland.

National Ironfounding Employers' Association

President: J. Smith, Smith & Company (South Shields), Limited, Mile Street, South Shields.
Secretary: Harold G. Judd, C.B.E., 8, Frederick's Place, E.C.2.

The Institute of Vitreous Enamellers

President: Dr. J. W. Mellor, F.R.S., Stoke Technical College, Stoke-on-Trent.
Chairman: W. H. Whittle, W. H. Whittle, Limited, Eccles, near Manchester.
Hon. Secretary: Miss E. Christine Elliot, 49, Wellington Street, Strand, London, W.C.2.

Foundry Trades' Equipment and Supplies Association

President: R. H. Brackenbury, 13, Victoria Street, London, S.W.1.
Secretary: K. W. Bridges, Grand Buildings, Trafalgar Square, London, W.C.2.

Welsh Engineers' and Founders' Association

President: W. E. Clement, Morfa Foundry, New Dock, Llanelly.
Secretary: E. J. Griffiths, 2, Royal Metal Exchange Swansea.

BRITISH CAST IRON RESEARCH ASSOCIATION

The Registered Office and Laboratories of the B.C.I.R.A. are:—
21-23, ST. PAUL'S SQUARE, BIRMINGHAM
Telephone: Central 1885. Telegrams: CIRA

The B.C.I.R.A. Scottish Laboratories are:—
Foundry Technical Institute, Meek's Road, Falkirk
Telephone: 332

Contents

	PAGE
A New Society	359
The History of Cast Iron.—II	359
The Institute of Vitreous Enamellers	360
International Foundry Conference, Brussels	360
Materials and Methods in Built-Up Welding	360
Random Shots	360
The Preparation of Steel to Avoid Porosity in Castings	361
The Iodine Method for the Determination of Oxides in Steel	364
Motor-Driven Air Compressors	365
Whitehead Iron and Steel Results	365
A Discussion on Patternmaking	366
Books Received	366
Some Factors which Influence Soundness in Non-Ferrous Castings	367
Metal Exchange Activity	368
Present-Day Practice and Problems of Welding in the Engineering Industries	369
"S" Monel Metal	370
This Week's News in Brief	372
Contracts Open	372
Personal	372
Notes from the Branches	372
Trade Talk	372
Financing New Cardiff Steelworks	372

A New Society

We have often heard Mr. J. G. Pearce complain that the results of research obtained by the British Cast Iron Research Association, and those emanating from other similar bodies, experience a time lag of about five years before they are absorbed and utilised by industry. We have visualised many remedies for this obvious defect in industrial development and have reached the conclusion that the fault lies in interrelated structure of British scientific societies. When a piece of research work is to be published on maybe steel, cast-iron or brass stampings, the author chooses the Iron and Steel Institute, the Institute of British Foundrymen or the Institute of Metals as being the appropriate society, or else an Institute containing users of such materials, such as the Institute of Mechanical Engineers, the Naval Architects, or the Automobile Engineers. In the former case he very rightly adds to the specialised knowledge of his own industry, whilst in the second his hearers imagine—often sub-consciously—that the author has an axe to grind. Cumulatively, each of these societies creates a mass of specialised knowledge which, as Mr. Pearce has so often insisted, lies dormant for a considerable period. For instance, our readers are familiar with all the recent advances in the production of high-duty grey-iron castings, but that avails them but little until such time as a really large body of designers is at least conversant with their uses. An odd lecture before a consuming technical institute is often regarded as "tainted."

It is with these thoughts in mind that we have been forced to the conclusion that there is room for a scientific society, the membership of which would be made up of technicians drawn from all phases of technical endeavour. This would ensure that the results of research produced by one section of industry would be disseminated with a minimum of delay to all other divisions. Such conditions exist in other industrial countries, and have there been thought to be advantageous. After all, it is the only logical method, in these days of intensive specialisation of disseminating information, of which non-specialists should be aware. Symposiums, joint meetings and the organisation of special lectures by experts from other branches have done nothing more than to emphasise the need for a recognised institute specially constituted for such a purpose.

The History of Cast Iron.—II

Continuing our account of conclusions reached by an American authority, Professor Read says that there is irrefutable evidence of the early casting of iron in China, because of the existence of the objects concerned. The largest is a cast-iron statue of a lion, 20 ft. high and 18 ft. long, at Tsangchow, probably the largest cast-iron statue ever made. The date of casting appears to have been 954 A.D. A bell in the Shansi province is dated 1079 A.D., and in the same province is a larger-than-life-size statue dated by an inscription on it as 1097 A.D. Four statues in Honan are dated 1213 A.D. In the "Thousand Buddha Hall" there were in 1920 no less than 225 cast-iron Buddhas, each about 30 in. high. A stone in the wall gives their date as 823 A.D., but a Japanese authority suggests that they were cast between 960 and 1127 A.D. In the same temple a record exists of the gift of a statue in iron in 738 A.D.

In 1909 a cast-iron stone was removed from a Han-dynasty grave in Shensi, described by an authority who also assigned cast-iron weapons to the period 25-220 A.D., and a Toronto museum contains Chinese cast-iron objects belonging to the period 206-220 A.D. The mould marks can be plainly seen on some of them, and others have been analysed and microscopically examined, and shown as a consequence to have been cast.

Furthermore, literary references carry Chinese cast iron back to the sixth century before Christ. In 115 B.C. the Chinese Government made a State monopoly of the iron industry. In 81 B.C. the Emperor heard a petition to have the monopoly abolished, and a State official argued that it made subjects so wealthy that they were encouraged to rebel against the State. An important use was making pans for evaporating brine.

Prof. Read concludes that the Chinese cast iron as early as the second, and possibly earlier than the sixth, century before Christ. If the Greeks made it first in the sixth century before Christ, it seems likely that the Greeks learned from the Chinese, for the latter made much and the former little, but there is little real evidence of a contact between these peoples so early. Prof. Read thinks the Greeks used it little, because in the West it was more expensive than bronze and harder to work with. We hope to deal with the remainder of this fascinating story, the working of iron in India, in a later issue.

XUM

The Institute of Vitreous Enamellers

A conference of The Institute of Vitreous Enamellers is to be held in Glasgow on June 8, 9 and 10, 1935. A technical meeting will be held on June 8, and will be attended by Dr. A. S. M. MacGregor, the medical officer of health for the City of Glasgow; Mr. H. E. Highton, the Secretary of the Department of Health for Scotland; and Dr. T. Ferguson, the acting chief medical officer of the Department of Health for Scotland. Lectures are being given by Dr. E. L. Middleton, M.D., D.P.H., H.M. Medical Inspector of Factories, and Dr. W. R. Jones, D.Sc.(Lond.), F.G.S., M.I.M.M. A full-day excursion on June 9 will provide an opportunity of spending a few hours among some of the most beautiful scenery in Scotland. On Monday, June 10, members will visit the City Chambers of Glasgow, and will be received by the Lord Provost, Sir Alexander B. Swan. This will be followed, in the afternoon, by a works visit, arranged by the courtesy of Messrs. Shanks & Company, Tubal Works, Barrhead, Renfrewshire.

Those meaning to attend the conference should write to Mr. J. G. Roberts, Messrs. Shanks & Company, Limited, Tubal Works, Barrhead, Renfrewshire, not later than June 1, 1935.

Programme

SATURDAY, JUNE 8.—3.0-4.30 p.m.: Members assemble in the lounge of the Central Hotel, Glasgow. 5.0-7.0 p.m.: Technical meeting in Lecture Theatre, Royal Philosophical Society of Glasgow, 207, Bath Street, Glasgow. 8.0 p.m.: Supper at Central Hotel.

SUNDAY, JUNE 9.—9.0 a.m.: Assemble at Central Hotel, Glasgow, for a motor-coach tour to Ardlui, Oban, and Cairndow, returning to Glasgow at 9.30 p.m.

MONDAY, JUNE 10.—10.0 a.m.: Assemble at Central Hotel, Glasgow. 10.15 a.m.: Visit City Chambers for civic reception at 10.30 a.m. by the Lord Provost, Sir Alexander B. Swan. 12.30 p.m.: Lunch at Central Hotel. 1.30 p.m.: Leave Central Hotel by motor-coach for visit to works of Messrs Shanks & Company, Limited, at Barrhead.

International Foundry Conference, Brussels

An International Foundry Conference will be held in Brussels from September 20 to 25, 1935. The preliminary programme is as follows:—

Friday, September 20, and Saturday, September 21.—Meetings of the Conference.

Sunday, September 22.—Reserved for individual action or for visit to the International Exhibition.

Monday, September 23.—Various excursions.

Tuesday, September 24, and Wednesday, September 25.—Meetings of the Conference.

It is also expected that, on the termination of the Conference, there will be a short tour through interesting portions of Belgium.

Members of the Institute of British Foundrymen, and ladies, are invited to take part in this Conference. A party will be formed by the Institute of British Foundrymen, and will leave London probably on Thursday, September 19. Visitors to the Foundry Conference will have opportunities of visiting the great International Exposition which is now being held in Brussels, and which was opened recently by His Majesty, King Leopold III.

Members of the Institute who are interested and would like to receive further particulars are requested to communicate with Mr. T. Makemson, St. John Street Chambers, Manchester, 3.

Materials and Methods in Built-Up Welding

At the Symposium on the Welding of Iron and Steel organised by the Iron and Steel Institute and held during the annual meeting of the Institute in London, GÜNTER ERBER, of Austria, presented a Paper on "Materials and Methods in Built-up Welding," in the course of which it was pointed out that any disturbances of stress distribution, such as might result from pockets, inclusions, cracks or unmachined surfaces, might have important effects on the strength of built-up welded work subject to alternating stresses. With a view to increasing the durability of such members all such disturbances of stress distribution should, in the first place, be avoided so far as possible. In the second place their effects should be mitigated by the use of welding material having a high notched-bar fatigue strength. An indication of this quantity was afforded by a figure which rose simultaneously with the tensile strength and the elongation.

The following series of recommendations emerge from these two fundamental principles:

(1) When a choice is possible the parent metal should have the lowest possible oxygen content and a low silicon content. Alloy steels should if possible be warmed before welding. (2) Bare electrodes should be used only when of particularly suitable composition; otherwise it is preferable to use cored or covered electrodes or to weld under gas protection. Nickel, aluminium, or (with correct working) manganese contents are advantageous. (3) Welding generators should be chosen from the point of view of their electrical characteristics to give the shortest period of voltage recovery. Infinitely variable current regulation is desirable. (4) To obtain good execution of the weld the strength and polarity of the current should be adjusted from time to time as required, even though the same electrode is being used. (5) Welds should be deposited in the same direction as the expected stresses. (6) Manganese-steel electrodes require that the work be quenched at a red heat. (7) The surface of a weld should always be machined; and (8) the work and materials require regular examination by means of test specimens.

(*Concluded from next column.*)

pounder, an expounder is a commentator, a common tater is an Irish tater, an Irish tater is a specked tater, a spectator is a beeholder, and a beeholder is a beehive.

* * *

Did you hear the story of the Aberdeen firm who posted a notice in their works before the Jubilee stating that, owing to the prolonged trade depression, the management regretted that they were unable to pay their employees for their holiday on Jubilee Day, but that, if trade improved, they would endeavour to pay them for the two minutes' silence in November?

MARKSMAN.

AT THE ANNUAL GENERAL MEETING of the Scottish Branch of the Institute of British Foundrymen, the following officers were elected for the next session: President: Mr. Daniel Sharpe, of Messrs. Walter Macfarlane & Company, Glasgow. Senior Vice-President: Mr. F. Hudson, of Glenfield & Kennedy, Limited. Junior Vice-President: Mr. D. Walker, of Mitchell, Russell & Company, Limited. Members of Council: Mr. J. McIntyre, Mr. H. Lowe, and Mr. A. L. Mortimer. Delegates to General Council: Mr. J. Affleck, B.Sc., Dr. J. W. Donaldson, D.Sc., Mr. J. McArthur, Mr. N. McManus, M.B.E., and Mr. Evan J. Ross. Representatives to Technical Committee: Mr. A. Campion and Dr. J. W. Donaldson. Honorary secretary and treasurer: Mr. John Bell.

Random Shots

The subject of price cutting finds few disputants. Most people adopt towards it the attitude of the Irishman to all forms of government; they are agin' it. The following fable illustrates the genealogical tree of the price cutter after the style of Æsop or La Fontaine.

* * *

At the beginning, when the world was young, the donkey was esteemed by all the tribes of men as the wisest of animals. The good Sheik El-Ev-Ator owned a great herd of these sagacious beasts, which was the pride and joy of his life. Other Sheiks from miles around came to listen and marvel at the wisdom of the herd. At such a time came even the prophet himself—most learned and wise of all the sons of Egypt. With much glowing of pride, El-Ev-Ator led him to the herd and said "Behold, O Prophet, the wise and talented asses. Converse with them, test them, and see if they are not verily wiser than forty trees full of owls." Then the prophet addressed the asses. "Let us test your wisdom," said he. "Answer me this question: what would an ass require for a three-days' journey?"

* * *

And they counselled among themselves and then made reply: "For a three-days' journey, O Prophet, any ass should require six bundles of hay and three bags of dates." "Very good," said the prophet, "that soundeth like a fair and proper price." Whereupon El-Ev-Ator broke into loud chuckles and said: "Did I not tell you they are passing wise?" The prophet answered "Wait," and he again addressed the asses. "I have for one of you," he said, "a three-days' journey, but I will not give six bundles of hay and three bags of dates for making it. Let him who will go for less stand forth?" Behold, they all stood forth and all began to talk at once. One would go for six bundles of hay and two bags of dates, then another for three bundles of hay and one bag of dates, until finally one specially long-eared ass agreed to go for one bundle of hay.

* * *

Then spoke the prophet. "Fool," quoth he, "you cannot even live for three days on one bundle of hay, much less profit from the journey." "True," said the long-eared one, "but I want to get the order." And from that far-off day to this, asses have been known as fools and price cutters known as asses.

* * *

One of "Marksman's" correspondents has sent him the following piece of applied logic, culled from a recent tour in the United States:

JUST YOU AND ME.

The population of the United States reported at	124,000,000
Those eligible for old-age pension under the Townsend Bill ...	50,000,000
	74,000,000
Number of persons prohibited under child labour laws and working Government jobs ...	60,000,000
Leaves just	14,000,000
Number of persons unemployed ...	13,999,998
Balance to produce the nation's goods	2

Just you and me, and I'm all worn out!

* * *

A man was heard the other evening proving to a few cronies that an ex-pugilist is a beehive. Here is his reasoning:—An ex-pugilist is an ex-

(*Concluded in previous column.*)

The Preparation of Steel to Avoid Porosity in Castings*

By C. E. SIMS, East Chicago, Ind., U.S.A.

Three principal sources can be assigned for the origin of porosity, namely, condition of the metal, condition of the sand or other mould materials, and construction of the mould. Method of pouring is undoubtedly a contributing factor in many cases, but is not here assigned as a principal source. So far as possible, this discussion will deal only with the first source—the preparation of the metal—and will be further confined to steel. The problem of porosity revolves around the fact that steel, in common with most other metals, shows a sudden decrease in its ability to hold gases in solution when the freezing point is reached. If molten steel contains sufficient gas in solution, there will be an evolution of gas during freezing, and part of this gas will be trapped within the body of freezing steel.

Nature of Solubility

In using the word "solution" as applied to gases in steel, it is used in its broadest sense, as meaning the retention of gases in the unfree state. Too little is known definitely about the mechanism of such solution, and whether it is due to "simple solubility," "chemical solubility," absorption where loose quasi-compounds are formed, or some electronic phenomenon as proposed by Lewis[1] (which rates a metal's ability to dissolve gas on its ability to dissociate the gas), is not known. Gottschalk and Dean[2] argue convincingly that the simple solubility of gases in metals must be close to zero. Certainly molten metal solutions of gas do not follow the laws of simple solutions as formulated for other liquids, such as aqueous solutions. Henry's law, which states that the solubility of a gas at a given temperature is proportional to the pressure of that gas above the solution, is openly flouted.

The law of Sieverts,[3] which calls for a variation of the solubility in accord with the square root of the pressure, is more nearly correct for most gas-metal solutions. Simple aqueous solutions of gas have a negative temperature coefficient; that is, the solubility decreases with rise in temperature. Metal solutions, on the other hand, have a positive coefficient, which causes the solubility to increase with rise in temperature. Moreover, this positive coefficient for molten metals is very much larger than the negative coefficient for known simple solutions.

Sieverts'[4] experiments indicate that the inert gases, such as argon, helium, neon, etc., do not dissolve in metals. A number of investigators report the complete insolubility of hydrogen and nitrogen in certain metals. On the other hand, Archer[5] found that when magnesium was melted under argon gas, gassy metal was obtained; whereas it was sound when melted under helium. Commercial gases were used in both cases, and there is the possibility that impurities may have caused the difference. The weight of evidence leans heavily to the probability of a chemical solution of some kind for gas in metal. The fact that the solubility of gases in molten metals is so extremely sensitive to slight changes in the chemical composition is easily explained by the theory of chemical solubility, but would be most difficult to explain on the basis of simple solubility.

Non-Concordant Results

Although a vast amount of work has been done by careful and experienced investigators on quantitative determinations of the solubility of gases in metals, there is a remarkable lack of agreement as to results. A number of reasons may be advanced as possibly explanations for these discrepancies. Imperfections in the delicate and complex apparatus used for the determinations may account for some of them. In dealing with such extremely small amounts, as in the analysis of gas in metal, a slight error may lead to a relatively large discrepancy. For instance, as quoted from Gottschalk and Dean,[2] "Two recent values for the solubility of hydrogen in silver at 800 deg. C. are 0.45 c.c. (Steacie and Johnson) and 0.73 c.c. (Sieverts) per 100 grams of silver, or 4 and 6.5 in 10 million parts by weight, respectively, or 1 atom of hydrogen respectively in 21,000 and 13,000 atoms of silver." It is only because of the relatively enormous volumes that gases have in comparison with their masses that makes it possible to work with such small quantities.

A more probable cause of the discrepancies is that certain aspects of the little-known gas-metal relationships have not been properly considered. The effect of minute quantities of impurities, uncertainties as to whether saturation has been reached, and loss of gas between the time of preparation and analysis of sample would all influence the results.

However, while we must accept, for the present, the postulate that the solubility of gases in metals is principally due to a chemical solubility or the formation of some kind of addition compound, there is the strong probability that there is also a slight but significant simple solubility as well. This complexity of solubility makes the problem of degasification or the control of porosity extremely more difficult than if only a simple physical solubility were involved. The gases that are of concern in steelmaking include oxygen, carbon monoxide, carbon dioxide, hydrogen and nitrogen. All of these gases are practically always evolved during the vacuum fusion analysis of steel. Small quantities of water vapour and gaseous hydrocarbons are also often found. Of these gases, the first three, namely, oxygen (O_2), carbon monoxide (CO), and carbon dioxide (CO_2), have an intimate interrelationship through the reactions of the system iron-carbon-ogygen, and these three elements are always to be found in steel.

Oxygen

The solubility of oxygen (O_2) in iron or steel is the solubility of iron oxide (FeO). This is especially evident in very hot or molten steel, where the high affinity of iron for oxygen precludes the possibility of more than the minutest quantities of elemental oxygen being present. Of course, some oxygen will always be present as oxides of foreign metals and metalloids, as, for example, MnO, Al_2O_3 and SiO_2. The solubility of oxygen in iron was determined first, both qualitatively and quantitatively by Tritton and Hanson,[6] who reported a saturation value at 1,535 deg. C. of 0.21 per cent., which is equivalent to 0.94 per cent. FeO. Herty and Gaines[7] determined the relationship between temperature and the solubility of FeO in iron. Their results check with those of Tritton and Hanson at 1,535 deg. C., and show that the solubility increases with temperature as a straight-line function until at 1,700 deg. C. there is 2 per cent. FeO present.

These figures, of course, apply to nearly pure iron with a slag consisting principally of FeO. Such concentrations would never be reached in practice. Actually, the amount of FeO in a bath of steel is dependent on the FeO content of the slag. The iron oxide always tends to divide itself between the slag and metal, according to a definite distribution ratio that varies with the conditions. Herty has shown that this distribution ratio is greatly affected by temperature. Ziegler[8] reports that the solubility of oxygen in solid iron is negligible below the critical temperature, but that above 900 deg. C. it increases rapidly with temperature and reaches a maximum at 1,000 deg. C. of 0.10 per cent., corresponding to 0.45 per cent. FeO.

Solubility Affected by Deoxidisers

As is well known, the solubility of oxygen in molten steel is enormously affected by the presence of other elements, principally the so-called deoxidisers, with which it reacts to form more or less insoluble oxides or other reaction products. Typical of these is the familiar reaction $FeO + C \rightarrow Fe + CO$. Theoretically, this reaction should proceed until the carbon and FeO reach definite proportions, representing equilibrium for the reaction. The constant for this equilibrium expressed as the product (per cent. FeO) × (per cent. C.) has been experimentally determined by Kinzel and Egan[9] as 0.0005. Experimental and calculated values have been reported elsewhere which vary all the way from this figure to that of 0.011 at 1,620 deg. C., found by Vacher and Hamilton.[10] From the free energy values, Chipman[11] calculated the constant to be 0.005 at 1,620 deg. C. Taking the last figure for example: when the carbon is 0.20 per cent., it should be possible to have only 0.025 per cent. FeO in liquid steel at 1,620 deg. C. Practically, we know that we can have more FeO for reasons which will be given in detail later.

Other typical reactions are:—

$$FeO + Mn \rightarrow Fe + MnO.$$
$$2FeO + Si \rightarrow 2Fe + SiO_2.$$
$$3FeO + 2Al \rightarrow 3Fe + Al_2O_3.$$

Chipman[11] has calculated equilibrium values for all of these reactions. The manganese reaction is complicated by the solubility of MnO. These values at three different temperatures are given in Table I. It is readily seen from Table I

TABLE I.—*Equilibrium Constants of Some Common Reactions in Steel.*

	1,500 deg. C.	At temp. of 1,600deg.C.	1,700 deg. C.
$\frac{\%\ MnO}{\%\ FeO \times \%\ Mn}$ =	4.55	2.30	1.25
$(\%\ FeO)^2 \times \%\ Si$ =	1.9×10^{-5}	1.5×10^{-4}	1.0×10^{-3}
$(\%FeO)^3 \times (\%\ Al)^2$ =	1×10^{-14}	7×10^{-13}	4×10^{-11}

that manganese alone is a poor deoxidiser, that aluminium is greatly more effective than silicon, and that all are more efficient deoxidisers at low than at high temperatures.

Carbon Monoxide and Carbon Dioxide

There is some uncertainty regarding the solubility of carbon monoxide and carbon dioxide (CO and CO_2) in steel. They are always to be found in the gases evolved from steel, either when solidifying or when subjected to vacuum treatment, either hot or cold. However, Klinger,[12] as reported in the Fourth Report on the "Heterogeneity of Steel Ingots,"[13] after an exhaustive study of the gases evolved from solidifying steel, reached the conclusion that CO and CO_2 were merely reaction products of the reaction $FeO + C \rightarrow Fe + CO$. These gases are not found when using the cold decomposition methods with iodine, and their solubility in steel must be denied. The work of Kinzel and Egan[9] on the equilibrium of the system iron oxide-carbon in molten iron, confirms this viewpoint and establishes the fact that CO and CO_2 are not appreciably soluble in molten steel.

Hydrogen

The fact of the solubility of hydrogen (H_2) in steel has been thoroughly established by a number of investigators. Sieverts'[14] made quantitative determinations of its solubility at various

* This Paper was presented and discussed at a Session on Porosity in Steel Castings held at the 38th Convention of the American Foundrymen's Association. The Author is Assistant Director of Research, American Steel Foundries.

temperatures and produced a curve which is shown in Fig. 1. It will be noted that there is a sharp break in the curve at the melting point. Ziegler[15] found no hydrogen in samples of steel prepared in the laboratory but found it in all commercial samples.

While the effect of most of the elements common to steel on the solubility of hydrogen is an unknown quantity, it is a well-established fact that oxygen has a large influence on the solubility, and also on the action of the hydrogen that is retained. This latter influence works through the reversible reaction $H_2 + FeO \rightleftharpoons Fe + H_2O$. Hydrogen gas may be used to deoxidise steel but not without saturating the latter with hydrogen. On the other hand, oxygen can remove excessive amounts of hydrogen. Neither can entirely eliminate the other.

Deoxidisers, like manganese, silicon and aluminium, are popularly credited with the ability to increase the solubility of hydrogen in steel by their presence. There seems to be no direct proof of this, however, and their evident effect may be due to their influence on the oxygen content.

Nitrogen

There is also considerable evidence to prove the solubility of nitrogen in steel. Svechnicov[16] reports that through the nitrifying of pure iron by means of ammonia, it is possible to obtain iron nitride (Fe_2N) with 11.1 per cent. nitrogen. The best condition for this reaction is at about 450 deg. C. With increasing temperature, the nitride decomposes and at 1,200 deg. C. all the nitrogen is removed.

Elemental nitrogen apparently does not dissolve in solid iron or steel but dissolves readily in molten steel. Strauss[17] reports 0.03 per cent. to 0.04 per cent. as the upper limit for nitrogen (N_2) in molten iron, although Dean, Day and Gregg[18] report having introduced 0.07 per cent. nitrogen by melting in air. However, commercial steels never contain any such quantity. Bessemer and electric-furnace steels are apt to contain the most nitrogen and will have from 0.010 per cent. to 0.024 per cent. Open-hearth steels contain from 0.003 per cent. to 0.008 per cent. nitrogen, while crucible steels have but 0.0005 per cent. to 0.002 per cent. The nitrogen absorbed by molten steel forms a stable nitride, which is not easily decomposed.

From a theoretical standpoint, Dean[19] has calculated that the absorption of nitrogen by pure iron could not be over 0.01 per cent. and probably is less than 0.005 per cent. Any amount present over this quantity is probably due to the presence of impurities. There is considerable evidence that impurities, such as manganese and more especially silicon, have a profound influence on the solubility of nitrogen. Silicon itself absorbs nitrogen avidly at steelmaking temperatures. Dean[19] believes the evidence points to silicon as the chief offender in introducing nitrogen into steel.

Coke Recarburisation and Nitrogen Increase

Experiments by Wust and Duhr[20] on duplex steel which was started in an open-hearth and finished in an induction furnace, show a sharp increase in nitrogen immediately following recarburisation with coke. In two heats reported, nitrogen increased in one from 0.005 per cent. to 0.0098 per cent. in 10 min., while in the other, it increased from 0.0028 per cent. to 0.013 per cent. in less than 2 hrs. Nitrogen had shown a loss during the preceding 5 hrs. in each heat. The nitrogen may have merely been in the coke, but it is more than likely that the increase is due to a change in the degree of oxidation of the steel. The highly-oxidised steel can contain only about 0.002 per cent. nitrogen, but as soon as the oxygen content is reduced, the nitrogen content increases. Perhaps this explains the action of silicon, manganese and aluminium in apparently increasing the solubility of nitrogen in steel. The presence of these elements acts against the presence of oxygen.

The Rôle of Equilibria and Surface Tension

In common with most chemical reactions, few metallurgical reactions go to completion. There is an equilibrium constant that sets a definite ultimate limit. But what is more important, is that reactions seldom reach true equilibrium. The law of mass action far overbalances the importance of stoichiometric proportions. Some reactions do not attain equilibrium because of the time factor. Steelmaking is a dynamic process, and things must be kept moving for economic reasons. At other times, a definite physical barrier may arise to stop a reaction short of equilibrium. Such a situation is present in the familiar reaction $FeO+C \rightarrow Fe+CO$, which is the reaction of decarburisation and which gives rise to the carbon boil. As noted earlier, the equilibrium constant for this reaction K = (per cent. Fe) × (per cent. C) is somewhere in the neighbourhood of 0.0005 to 0.005. As a matter of everyday experience, it is known that the boil often ceases when this product is as high as 0.03, or, in other words, when there is from 6 to 60 times as much FeO present as would be possible under equilibrium conditions for a given carbon content. Under

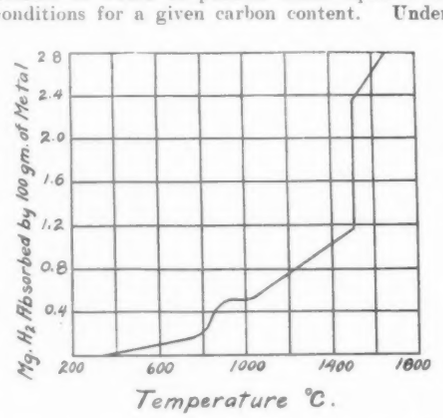

Fig. 1.—The Effect of Temperature on the Solubility of Hydrogen in Iron (Sieverts).

these conditions there exists an apparent equilibrium, as evidenced by the absence of any action.

The explanation for this as advanced by Gaines[21] is "—— that a large excess of FeO is necessary in order that the CO may develop sufficient pressure to form a gas bubble. This is due to the tremendous compressive force of the iron on the minute bubble of gas. This pressure is a result, not of the ferrostatic head, but of the surface tension of the iron itself, which is very large." This makes it very difficult for a bubble to start, but once started, gas diffuses into it rapidly from the surrounding liquid.

Another example is the reaction $2H_2+O_2 \rightarrow 2H_2O$. This reaction, if considered in the gaseous phase, proceeds rapidly and rather completely from left to right. But where the oxygen and hydrogen are present in a molten metal, as oxide and hydride, respectively, it requires a large excess of available oxygen to remove the hydrogen as the gaseous product H_2O. The surface tension barrier to bubble formation presents a number of ramifications. For instance, Bircumshaw[22] found that he could not pump off the hydrogen in molten aluminium by vacuum treatment for 114 hrs. On the other hand, it has been found that hydrogen can be removed from both aluminium and copper by bubbling a neutral gas, such as nitrogen, through the molten metal.

This explains the value of the carbon boil as a degasifier for steel. According to the law of Sieverts, the solubility of gas in metal varies as the square root of the partial pressure of that gas in the atmosphere adjacent to the metal. Theoretically, all that would be necessary to rid a molten metal of dissolved gas would be to provide it with an atmosphere free from that gas. Practically, this would be an endless process because the escape of the gas would all have to be at the surface. Take the case of a steel bath containing hydrogen. During the carbon boil, the bubbles of CO gas formed have a partial pressure of zero for hydrogen at the time of formation. For this reason hydrogen will immediately diffuse into them. Naturally each bubble would contain but a small proportion of hydrogen, but with the millions of bubbles being formed throughout the boil, there is opportunity for the bulk of the hydrogen or nitrogen to be removed.

As was apparent from the data given earlier on the equilibrium constants of the various deoxidisers, temperature plays a very important part in both the absolute and relative concentrations of elements other than iron in a bath of molten steel. For instance, at high temperatures, not only is the solubility of FeO increased, but also a higher concentration is necessary to oxidise carbon at a given content. At low temperatures, just after a charge of steel is melted, first silicon and then manganese is oxidised almost quantitatively by additions of FeO before any appreciable amount of carbon is eliminated. Increasing temperatures tend to reverse this condition; and when the temperature is high enough, silicon will be retained, while carbon is oxidised, or, in the absence of silicon in the steel, carbon will reduce it from the slag unless the latter is too basic. In Bessemer converters, where the temperature sometimes runs very high, it has been possible to oxidise the carbon while retaining as high as 1 per cent. silicon.

Sources of Gases in Steel

Of the gases which at times cause trouble in steel, it has been shown that CO and CO_2 are reaction products of C and FeO. Although it is sometimes introduced physically by certain conditions that are set up in a mould, H_2O is also principally a reaction product. Some hydrogen and nitrogen already is contained in the pig-iron and scrap that constitute the furnace charge. Also, the ferro-alloys used in deoxidising are known to contain both these gases.

The atmosphere of an open hearth furnace is always rich in nitrogen and water vapour, and usually contains some free hydrogen. Water vapour is oxidising to hot steel, and hydrogen is liberated by the reaction $H_2O+Fe \rightarrow H_2+FeO$. There is no flow of combustion gases through an electric furnace, and the atmosphere should ostensibly be freer from hydrogen and nitrogen. Nitrogen will always be present, however; and considerable quantities of a hydrated oxide, known as rust, provide a potential source of hydrogen. There is unquestionably some absorption of both hydrogen and nitrogen at the high temperatures preceding and during melting, but this has not yet been determined quantitatively.

When the steel is melted and is covered by a slag, the chances for further gas absorption might seem to be nil. The gas content of slags (except, of course, for oxygen) is entirely an unknown quantity, yet there is room for at least a strong suspicion that slags may act as gas carriers. Take for instance the most promising case: that of a basic electric furnace slag containing carbide. It is perfectly logical to suppose that it might also contain calcium cyanamide. And last, but not least, is the effect of contact with the air and mould-gases during tapping and pouring.

Significant Examples

A rimming steel is the most common example of a porous steel, made purposely so to achieve a definite end. The principal gas evolved during the freezing of a rimming ingot and the only gas desired is CO. The evolution of CO is due

to the familiar reaction $FeO+C \rightarrow Fe+CO$, suddenly made more active by a shift in the equilibrium constant, which, in turn, is brought about by the rapidly decreasing temperature. This reaction can be rather nicely controlled by judicious use of deoxidisers, such as aluminium. This regulation of the FeO content modulates the violence of the effervescence and thus determines whether the gas-holes shall be near the skin of the ingot or deep seated.

But when the steel contains an excess of hydrogen, it almost invariably appears as undesirable skin-holes in the ingot. These hydrogen holes cannot be controlled with deoxidisers, and can be prevented only when sufficient deoxidiser is added to produce a piping ingot, or in other words, to produce a deoxidised or "killed" steel. It has been shown, however, that a sufficiently vigorous boil will carry off enough hydrogen to prevent these skin-holes. A high residual manganese (Mn), say, above 0.15 per cent., greatly increases the danger of skin-holes, and the charge is purposely kept low in this element, usually about 0.20 per cent. The action here is probably not a direct effect of Mn, but a high residual Mn reduces the ogygen content of the steel and causes a more gentle boil.

In acid-electric furnace practice it has been amply demonstrated that a heat, melted low in carbon and finished without a boil, will be so gassy as to almost effervesce in the moulds, and no amount of deoxidiser, aluminium included, will make it sound. A high residual silicon, or conditions that will cause reduction of silicon from the slag, set the stage for gassy steel. The obvious remedy is a higher degree of oxidation.

Effect of Oxygen on Solution of Hydrogen

Personally conducted laboratory experiments in a high-frequency induction furnace have shown that a charge of steel when melted and finished by deoxidation with ferro-manganese and ferro-silicon in a certain way will yield a sound casting. Another charge handled in just the same way, except that a stream of hydrogen is directed against the bare surface from a partially-submerged tube, before it is deoxidised, will still yield a sound casting. If, however, the procedure be changed so that the stream of hydrogen is introduced after deoxidation, the resulting casting will have more void than solid. The presence of the oxygen in the first case prevented the solution of the hydrogen, or perhaps oxidised it as fast as it dissolved. Eventually, of course, all the oxygen would have been used up and the hydrogen would then have gone into solution.

"It has been demonstrated[17] that liquid liquid copper, containing comparatively large quantities of hydrogen, can be cast into ingots without the formation of blow-holes, provided that the necessary precautions are taken to protect the metal from becoming contaminated with oxygen, either before or during casting. If, however, the same metal is allowed to absorb oxygen during casting, a very large number of blow-holes are formed in the ingot." In the absence of oxygen, the surface tension prevents the initial formation of hydrogen bubbles. With oxygen present, the falling temperature causes a reaction with hydrogen to form water vapour. This latter being quite insoluble, with resultant high vapour pressure, forms small bubbles into which the hydrogen rapidly diffuses.

The action in steel is entirely analogous. With comparatively small quantities of hydrogen, a steel will solidify porous if not sufficiently deoxidised, *i.e.*, if the oxygen content is not brought low enough to prevent a reaction with the hydrogen. As an indication of what is meant by small quantities, Merica[23] has calculated that the presence of 0.0002 per cent. hydrogen in free form in a casting will render it so porous as to be useless. As the hydrogen content increases, a correspondingly smaller concentration of oxygen is required to prevent reaction. It has been shown that silicon will not completely deoxidise steel, and that explains why it is sometimes necessary to use a stronger deoxidiser, such as aluminium, to prevent porosity. When porosity is thus prevented, the hydrogen remains as a supersaturated solid solution. However, if the degree of supersaturation is enough so that the pressure exceeds the surface tension of the steel, hydrogen will be evolved, and aluminium is powerless to stop it.

Most of the comments regarding hydrogen, with the exception of its reaction with oxygen, apply similarly to the action of nitrogen. There are, of course, extraneous influences that will cause porosity, as, for instance, migrant mould gases. A little water vapour introduced from this source might easily have the same effect as water vapour produced by internal reaction, except that its action will be local. But, as this is the subject of another Paper, it will not be considered here except as to suggest that the greater the margin of safety against spontaneous evolution of gas in the steel, the less are the chances that migrant gases will cause porosity.

Experiments made in an induction furnace have led to the following observations. A heat of steel that would otherwise give a sound non-porous casting, will yield a porous casting if poured over a green spout that causes it to "boil" from the water vapour given off. Steel can be safely superheated to a considerable degree before deoxidation, but the same amount of superheating after deoxidation is apt to result in porosity. Generally speaking, heats made without excessive gas content and deoxidised with manganese and silicon will be porous if the silicon is below about 0.25 per cent., and sound if the silicon is higher.

Although there is no intention to make 0.25 per cent. silicon an arbitrary minimum, experience has shown that under average conditions it is dangerous to go below that range in casting steel. The actual danger point will vary with other conditions, and in practice, a safe margin will be used. The first gas to be evolved with a decreasing silicon content is probably H_2O rather than CO. Experience with rimming steel indicates that silicon in quantities of more than a few hundredths of a per cent. seriously affects its rimming qualities. It is probable that CO can be discounted entirely as a primary factor in causing porosity, considering the silicon contents normally used in casting steel. Nevertheless, for reasons already given, when gas evolution is once started, the evolved gases would most certainly contain CO.

Summary

The "simple solubility" of gases in metals is extremely low. Gases in metals occur in "chemical solution" as oxides, hydrides, nitrides, etc.

CO and CO_2 are insoluble in steel and occur only as reaction products.

Hydrogen and nitrogen are both soluble in liquid steel as hydride and nitride, respectively.

The solubility of hydrogen and nitrogen is affected by the oxygen content.

The effect of deoxidisers on the solubility of hydrogen and nitrogen is due to their effect on the free oxygen content.

The resistance to bubble formation, caused by the high surface tension of steel, plays a very important part in the retention of gases.

This surface tension is overcome, and gas evolution takes place in the presence of bubbles of a neutral gas.

Although not offered as a positive conclusion, it seems logical to regard all "dead" or "killed" steels at their freezing point as containing gases in varying degrees of supersaturation. These gases under favourable conditions will be retained in solid solution, but are potentially capable of causing porosity.

The porosity problem resolves itself to (1) reducing dissolved gases to the lowest possible content, and (2) producing the conditions most favourable for retaining in solid solution those gases that could not be eliminated.

Conditions favouring low gas content:—(1) Long, vigorous boil; (2) thorough oxidation; (3) low residual silicon and manganese; (4) moderate temperatures; (5) no increase in temperature after deoxidation; and (6) late deoxidation. Conditions favouring retention of gases in solid solution during freezing:—(1) Thorough deoxidation, and (2) minimum exposure after deoxidation. Control through selection of charge and control of atmosphere at present seems both impractical and unnecessary. More fundamental data on the gas-metal relations are urgently needed.

BIBLIOGRAPHY.

1 Lewis, W. C. McC., "Jnl. Chem. Soc.," v. 26, pp. 152–77 and 202–18, 1929.
2 Gottschalk, V. H., and Dean, R. S., "The Solubility of Gases in Metals," "Trans. A.I.M.M.E.," Preprint, 1932.
3 Sieverts and Krumbhaar, "Zeitschrift fuer Physikalische Chemie," v. 74, p. 277, 1910.
4 Sieverts, A., "Die Aufnahme von Gasen durch Metalle," "Stahl und Eisen," v. 48, p. 1251, 1928.
5 Archer, R. S., private communication.
6 Tritton, F. S., and Hanson, D., "Ferrous Alloys Research, Part II—Iron and Oxygen," "Jour. Iron & Steel Inst.," No. II, p. 90, 1924.
7 Herty, Jr., C. H., and Gaines, Jr., J. M., "Effect of Temperature on the Solubility of Iron Oxide in Iron," A.I.M.M.E. Tech. Pub. No. 88, 1928.
8 Ziegler, N. A., "Solubility of Oxygen in Solid Iron," "Trans. A.S.S.T.," v. 20, No. 1, 1932.
9 Kinzel, A. B., and Egan, J. J., "Experimental Data on the Equilibrium of the System Iron Oxide-carbon in Molten Iron," A.I.M.M.E. Tech. Pub. No. 230, 1929, Abstract, "Jour. Iron & Steel Inst.," 1930.
10 Vacher, H. C., and Hamilton, E. H., "The Carbon-Oxygen Equilibrium in Liquid Iron," "Trans. A.I.M.M.E.," v. 95, p. 124, 1931.
11 Chipman, John, "Application of Thermodynamics to the Deoxidation of Liquid Steel," "Trans. A.S.M.," v. XXII, No. 5, 1934.
12 Klinger, P., "An Investigation of the Gases Evolved on the Teeming and Solidification of Steel," "Kruppsche Monatshefte," v. 6, p. 11, 1925, Abstract, "Jour. Iron & Steel Inst.," No. I, p. 525, 1925.
13 Report by a Joint Committee of the Iron and Steel Institute and the National Federation of Iron and Steel Manufacturers to the Iron and Steel Research Council.
14 Sieverts, A., "Solutions of Gases in Metals," "Zeitschrift fuer Electrochemie," v. 16, p. 707, 1910, Science Abs., p. 597, 1910.
15 Ziegler, N. A., "Gases Extracted from Iron-Carbon Alloys by Vacuum Melting," A.I.M.M.E. Tech. Paper No. 168, 1929.
16 Svechnicov, V. N., "Effect of Nitrogen in Iron and Steel," "Blast Furnace and Steel Plant," July, 1929.
17 Strauss, B., "Mikroskopishe Stahl Untersuchung," "Stahl und Eisen," v. 34, p. 1814, 1914.
18 Dean, R. S., Day, R. O., and Gregg, J. S., "Relation of Nitrogen to Blue Heat Phenomena in Iron and Dispersion Hardening in the System Iron-Nitrogen," A.I.M.M.E. Tech. Pub. No. 193, 1929.
19 Dean, R. S., "The Absorption of Nitrogen by Steel," U.S. Bur. Mines, Rep. of Inves. No. 3076.
20 Wust, F., and Duhr, J., "Ueber ein Stickstoffbestimmungsverfarhen in Stahl und Roheisen und über den Stickstoff bei den Hüttenprozessen," "Stahl und Eisen," v. 42, 1922.
21 Gaines, Jr., J. M., "Certain Methods of Deoxidising Steel," "Blast Furnace and Steel Plant," January, 1930.
22 Bircumshaw, L. S., "The Solubility of Hydrogen in Tin and Aluminium at High Temperatures," "Phil. Mag.," p. 510, 1926.
23 Merica, Paul D., "Gases in Metals," "Mining and Metallurgy," April, 1931.

B.S. Multitubular Horizontal Boilers

The British Standards Institution has issued B.S.S. No. 609—1935, Multitubular Horizontal Boilers, which is the second of the projected series of specifications for land boilers. This specification deals with horizontal multitubular boilers of dry-back and waste-heat types, and is generally similar to the specification issued last year for Lancashire and Cornish boilers, but includes, in addition, appropriate provisions and rules for tubes and bar stays. It excludes setting, insulation and furnace fittings, mechanical stokers, air pre-heaters and similar auxiliary gear, which are to be the subject of mutual agreement. The Specification comprises sections dealing with materials, rules for scantlings, construction, workmanship and inspection, makes provision for certain alternatives and is complete with inquiry and tender appendices. The rules for scantlings are applicable only to boilers constructed throughout under independent supervision and when working under normal average conditions of draft, good feed water and adequate maintenance supervision. It is recommended that when conditions are adverse, *e.g.*, abnormal evaporation, bad feed water, exposure to the elements, or where neglect is anticipated or inevitable, that the minimum scantlings specified should be increased by an appropriate addition to the working pressure in the rules. The specification is comprehensive and complete, and while the particular alternatives required must be selected, the appendices render this a simple matter. Copies of this specification may be obtained from the Publications Department, British Standards Institution, 28, Victoria Street, London, S.W.1. (Price 2s. 2d. post free.)

The Iodine Method for the Determination of Oxides in Steel

By T. E. ROONEY and A. G. STAPLETON

[*Abstract of Paper read at the annual meeting of the Iron and Steel Institute.*]

The iodine method for the estimation of oxides in steel may be described as a "residue method." It consists in dissolving a sample of drillings in a solution of iodine, filtering, igniting and weighing the insoluble residue. The ignited residue is examined for silica, oxides of iron, manganese and aluminium, etc. Various modifications of the method have been proposed which differ mainly in the composition of the iodine solution. Willems used an alcoholic-iodine solution and filtered through an ultra-filter in order to retain very fine particles of the residue.

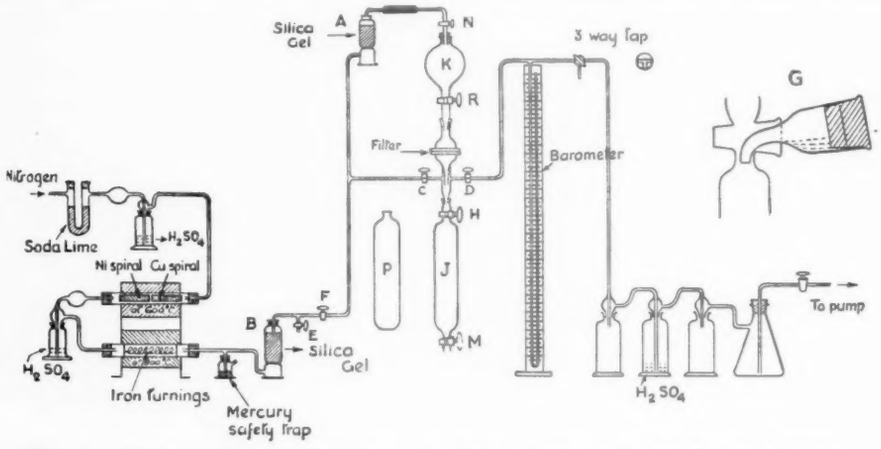

FIG. 1.—APPARATUS FOR THE ESTIMATION OF OXIDES IN STEEL BY THE IODINE METHOD.

As a result of the experience gained in the use of the method at the National Physical Laboratory the apparatus and procedure have been somewhat modified. The modified apparatus is illustrated in Fig. 1. The main alterations consist in the use of a small mercury safety trap for the nitrogen stream, the introduction of a silica-gel tower at A and the use of a "dry" purification train for the nitrogen in place of the alkaline pyrogallol used by Bannister. Silica-gel was also substituted for the soda-lime used by Bannister in the tower at B. As the success of the method depends on the exclusion of all traces of moisture from the apparatus and the reagents, the efficiency of the gas-purification train is very important, and the use of soda-lime as an acid trap at the end of the train is rather risky. The removal of traces of oxygen may not be so important, but it is an additional safeguard. Another point worthy of mention is that only dry gas is allowed to enter the apparatus through tap C, and evacuation is carried out only through tap D. This obviates any risk of contaminating the apparatus by moisture and other vapours carried away during evacuation.

The nitrogen is purified by passing through a U-tube containing soda-lime in order to remove traces of carbon dioxide. It is then dried by bubbling through concentrated sulphuric acid, and passes into a combustion tube which is maintained at a temperature of 600 deg. C. The combustion tube contains spirals of copper gauze and of pure nickel gauze. From this tube the gas passes through another sulphuric-acid bottle, and then into another combustion tube containing pure iron turnings which are maintained at a temperature of 800 deg. C. The sulphuric-acid bottles are provided with safety traps. Finally the nitrogen is conducted through a tower containing silica-gel before entering the apparatus through a tap at F. A by-pass at E is provided with a tap. The delivery tube is divided into two branches so that nitrogen can be admitted through the taps C or N. The apparatus can be evacuated through the tap D.

The sample is used in the form of millings, and great care is exercised in their preparation. A special milling machine is employed which is reserved for those purposes in which it is essential to avoid contamination during the preparation of a sample for analysis (pure metals, etc.). The machine is enclosed in a cubicle in order to ensure freedom from dust and moisture. A cleaning cut is made so as to remove any effects of surface oxidation or other contamination. Immediately the millings have been prepared they are carefully dried in a stream of nitrogen. A portion is then inserted in the weighing bottle G, weighed and transferred through the tap H into the reaction vessel J. The bottle is re-weighed. The reaction vessel is placed in a horizontal position, the millings are spread out as much as possible and a slow stream of dry nitrogen is passed through by connecting to the by-pass at E. The gas stream is continued overnight in order to displace the air and thoroughly dry the vessel and its contents.

Seventy grammes of pure iodine, previously dried by storing over silica-gel, are placed in the tap funnel K and dissolved in 600 ml. of pure dry methyl alcohol. Anhydrous methyl alcohol is a commercial product and has been found to be much more reliable than ethyl alcohol for this purpose. To ensure that it is free from traces of moisture it is distilled two or three times over calcium.

The iodine solution is filtered through either a "Cella" ultra-filter or a No. 50 Whatman filter. The filter is dried by soaking in methyl alcohol for about 10 min., blotted between filter paper and fitted between the flanges at L. The flanges are first smeared with vaseline and are held together by means of spring clips to ensure a tight joint. The filter is supported on a perforated glass disc, but here again an improvement can be effected by the use of a fritted-glass disc with fused edges which speeds up the filtration. The filter is washed three or four times with methyl alcohol with slight suction, the filtrate being received in the vessel P. The apparatus is then assembled as shown in Fig. 1, the taps at R, H and M being closed. The tap at C is closed and that at D opened. A slow stream of nitrogen is allowed to enter at tap N in the funnel K. The taps at R and H are opened and the iodine solution is filtered into the reaction vessel with slight suction. Tap H is closed near the end of the filtration so as to retain a slightly reduced pressure in the reaction vessel. The reaction vessel is then disconnected and fixed securely in a felt-lined wooden box. The box is mounted on trunnions and is slowly revolved by means of a small geared motor. The iodine solution is thrown from end to end of the reaction vessel. The churning is continued until all the steel is dissolved, usually in about two to three hours. A magnet may be used to determine when solution is complete.

TABLE I.—*Total Residues.*

Carbon (per cent.).	Total ignited residue (per cent.).	
	"Cella" filter.	Whatman filter.
Carbonyl iron.	0.100	0.107
0.10	0.079	0.081
0.40	0.093	0.094
0.40	0.092	0.092
0.40	0.096	0.094
0.60	0.108	0.108

Another filter is prepared as previously described, and the funnel K is removed and replaced by the reaction vessel above the filter. The vessel P is fixed below the filter. Tap H is cautiously opened to admit nitrogen to the reaction vessel, and then tap M is opened and the liquid is filtered with slight suction. The reaction vessel is washed down three or four times with methyl alcohol and, after draining, disconnected. The filter is washed with methyl alcohol until free from iodine and suction is continued until the filter is dry. The residue on the filter should be black or dark grey. The edges of the filter which have been clamped between the flanges are difficult to wash free from iodine and should therefore be trimmed off. The filter with the residue is ignited in a small platinum crucible and weighed.

TABLE II.—*Analyses of Residues.*

	Carbonyl iron.	Steel, carbon 0.10 per cent.	Steel, carbon 0.40 per cent.	Steel, carbon 0.60 per cent.
Weight of sample. Grms.	9.1698	8.3808	8.2732	6.4612
,, residue. Grms.	0.0092	0.0066	0.0076	0.0070
Residue (per cent.)..	0.100	0.079	0.092	0.108
Weight of SiO_2. Grms.	0.0002	0.0006	0.0008	0.0008
,, Fe_2O_3. Grms.	0.0088	0.0019	0.0040	0.0020
,, Al_2O_3. Grms.	—	0.0018	0.0015	0.0012
,, Mn_3O_4. Grms.	—	0.0026	0.0010	0.0030

In the procedure described by Bannister the apparatus and filter are dried before each operation by evacuating two or three times and washing out with dry nitrogen. The procedure described above is simpler and safer in operation as there is less risk of moist air leaking into the apparatus, and considerable time is saved. The filtration of the iodine solution into the reaction vessel usually occupies about 20 to 30 min. and the filtration of the liquid after the reaction occupies 40 to 50 min.

(*Concluded on page* 368.)

Motor-Driven Air Compressors

FOR SERVICE IN INDIA AND SOUTH AFRICA

The two-crank, two-stage, double-acting compressor illustrated is one of a number recently built by J. Browett-Lindley (1931), Limited, of Letchworth, for service in India and South Africa. The set is designed to deliver 1,000 cub. ft. of free air per min. at 100 lbs. pressure per sq. in. and is driven by a motor at a speed of 365 r.p.m. The high- and low-pressure air cylinders are 21 in. dia. and 13 in. dia. respectively and the stroke is 10 in. Each cylinder with its valve box is a separate casting. The cylinders and covers are water-jacketed and large doors are provided for cleaning them out should this become necessary.

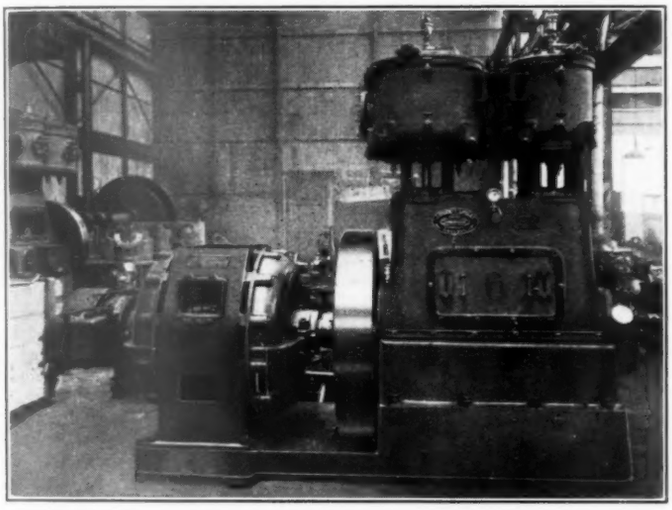

FIG. 1.—BROWETT-LINDLEY 1,000-CUB. FT. MOTOR-DRIVEN AIR COMPRESSOR.

The valves, actually the heart of a compressor, are on both the suction and delivery sides, and are of the Browett-Lindley ring plate (Hoerbiger) type. The working part of this valve is a thin plate of special steel which is held rigidly at the centre by an axial screw. The plate is ingeniously cut to give free elastic rectilinear movement with the least possible resistance. As there are no wearing surfaces, lubrication is unnecessary. Experience has shown that even after long service at high pressures there is no leakage, as the valve plate gradually adapts itself even more truly to the highly-finished surface of the seat. Owing to the small lift of the valve plate it is practically silent at all speeds. The shock of opening is reduced by a cushion plate of thin steel, an arrangement which is also conducive to quiet running. Lift washers are fitted between the valve seat, plate and cushion plate, the combined thickness of these washers being equal to the lift of the valve. To facilitate the closing of the valve, as also to keep the plate firmly in contact with its seat when closed, a spring is fitted in each recess of the guard.

The air pistons are of cast iron, machined all over, and are fitted with deep spring rings designed to exert a uniform pressure at all points of the circumference with a minimum of friction. Cone and shoulder springs are provided for the pistons. The cross-head is fitted with a pair of renewable cast-iron slippers and phosphor-bronze bushes for the connecting-rod pin, these bushes being adjustable by means of cap and bolts. The flywheel is mounted on an extension of the crankshaft and its weight supported by an outer bearing. An intercooler comprising a cast-iron cylinder fitted with brass tubes through which the cooling water circulates is carried on a cast-iron stool. Forced lubrication is, of course, provided for the whole of the motion work.

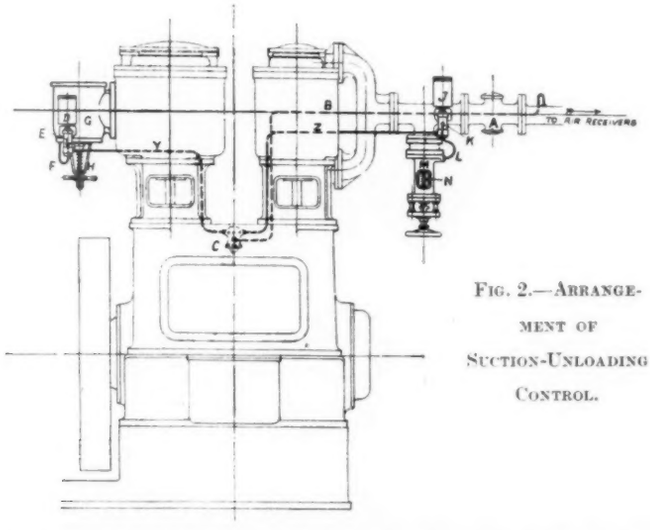

FIG. 2.—ARRANGEMENT OF SUCTION-UNLOADING CONTROL.

Suction-unloading control is provided by an automatic unloading valve on the air inlet. The object of this valve is to unload the compressor automatically by preventing air from being drawn into the first stage when the demand for air ceases and it is not desirable to stop the compressor. The operation of the valve is, briefly, as follows. When the air demand falls or is temporarily suspended, the receiver pressure rises 3 to 5 per cent. above normal so that the air-relay governor D (Fig. 2) operates, uncovering port E and causing the spring-loaded piston of the throttle valve G to rise and so close the inlet. Immediately the air pressure is reduced to normal owing to increased demand, the spring H opens the air-inlet valve, allowing air to pass freely into the compressor. Whilst this control will probably find most favour, the makers fit several other types to meet individual requirements.

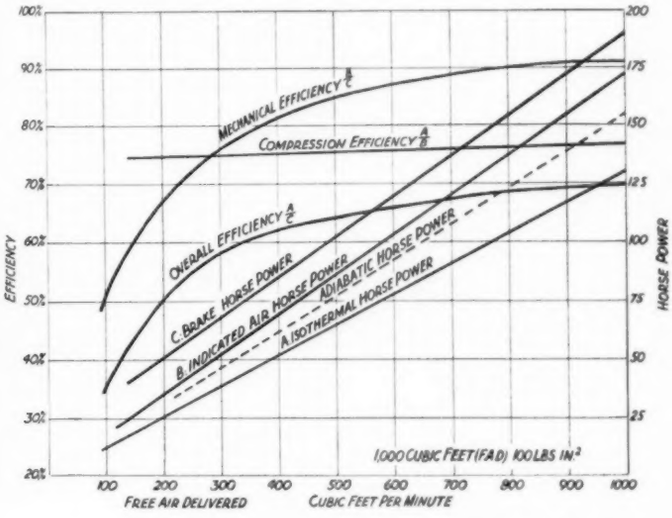

FIG. 3.—CHARACTERISTICS OF BROWETT-LINDLEY TWO-STAGE COMPRESSOR.

The specially-widened bed upon which the compressor is carried has no doubt a bearing upon the quiet running of the set, as well as on the elimination of vibration. The characteristic curves (Fig. 3) are self-explanatory. It may, however, be mentioned that the free air delivered was checked by the following three methods: (*a*) Nozzles and method of the British Compressed Air Society; (*b*) nozzles in high-pressure main, and (*c*) measurement of volumetric efficiency from low-scale spring indicator diagrams.

Whitehead Iron and Steel Results

Preliminary figures for the year ended March 31 last show a rise in the net profit of the Whitehead Iron & Steel Company, Limited, from £73,734 to £187,000. The directors propose recommending a final dividend of 10 per cent. (actual), making 20 per cent. for the year, and, in addition, a cash bonus of 10 per cent. (actual), both less tax. In the previous year, the final dividend was 10 per cent., making a total of 15 per cent. It is also proposed to make a bonus distribution of one share in four.

Determination of Slag Inclusions

Slag inclusions in siliceous iron were found to be aluminium silicate, alumina, silica and traces of manganese and iron silicates, according to I. T. LUKASHEVICH-DURANOVA in "Soob. Vseso. Inst. Met.," alumina being the most harmful constituent.

A Discussion on Patternmaking

MACHINE-MADE PATTERNS CRITICISED

Patternmaking and its relationship to moulding was the subject of discussion at a meeting of the West Yorkshire Branch of the Institute of British Foundrymen, held at Bradford Technical College.

Mr. A. W. Walker presided. Mr. G. Copeman, of Leeds, had been announced to give a Paper entitled "Complex Patternmaking Problems," but what Mr. Copeman actually gave was an entirely informal, though comprehensive, talk on patternmaking and its difficulties and the important effects it has on the economics of foundry practice. The talk elicited a discussion of equally informal character, in the course of which there was plentiful reference, of a playful character, to the time-honoured disagreements between patternmakers and moulders as to which is the section of the craft on whom the chief responsibility of deep thought rests, and which is the party really to blame if things go wrong!

MR. COPEMAN said he wanted to say quite frankly, at the outset, that he had not come that evening armed with a Paper full of data and technical knowledge. He desired only to speak a little on patternmaking from practical experience gained during his working life in that job. Many people, including many people in the foundry and engineering industries, had but a vague idea of what patternmaking really was, or how it was carried out, and he would like to give his hearers a general idea as to what a patternmaker must know. The patternmaker (proceeded Mr. Copeman) must, to start with, be able to read a draughtsman's drawing, and therefore he should have some knowledge of the methods of the drawing office. There was often difficulty in making, and equal difficulty in interpreting, a complicated drawing and the projection of views. The good patternmaker was a man who had had some personal experience in the foundry, and therefore had some knowledge of the moulder's difficulties and in making patterns endeavoured to minimise the difficulties likely to be encountered by the man in the foundry. Only the patternmaker who had had foundry experience could meet this need adequately, and it was unfortunate that so many patternmakers, excellent woodworkers, never had a chance of entering the foundry. There were some, he agreed, who had themselves no interest beyond the pattern, but he did not regard them as good patternmakers, even if they were good joiners. In other cases the patternmaker was not welcomed in the foundry, and if he ventured in was able to glean little or nothing of a character which would help him to work with an eye to easing the foundryman's problems. In this regard Mr. Copeman made some comparisons between the patternmaker employed in a works with their own foundry and a willingness on the part of the foundry people to welcome co-operation, and the patternmaker working in a place whose product was sent out to foundries. This man was obviously at a disadvantage.

Choice of Timber

Proceeding to considerations of the patternmaker's work, Mr. Copeman said there was a right and a wrong way to select one's timber, and as far as possible all end grains of the wood should be cut out in making up the structure, because end grains were liable to chip off. This resolved itself, of course, into a matter of "finish," and finish was one of the most important points from a practical standpoint as well as merely for appearance and lasting value. Some firms worked to so fine a degree of accuracy that decimal points, even the thickness of varnish or paint, affected the pattern in regard to size, and there was no doubt at all that the avoidance of a great deal of difficulty for moulders depended on the craftsmanship of the patternmaker. In some large shops they had men employed especially to lay out the timber for the actual patternmaker, but Mr. Copeland said he was referring to the general jobbing shop, where the patternmaker laid out his own timber and did the whole job throughout, and it was in many of these places that a man was handicapped by having to work without any knowledge of the foundry to which the pattern was going or the conditions under which it would be used. He had to be prepared to make, if possible, a pattern which would work easily and with reasonable satisfaction under a lot of different foundry conditions. The patternmaker had to imagine at the start what the job was going to be, and he had to make it so that the cores would go in and out easily and not merely have the thing the correct shape. It was a great help when he was able to see in advance an actual job of the same kind finished, but often he had nothing at all to depend upon but the drawing.

Contraction Rule

The contraction rule had to be regarded most carefully, as it was not always safe to work to, owing to the differences in metal and design of the work. The different contractions on the same rule might seriously mislead the patternmaker, for each turn of the rule made all the difference in dimensions in respect of iron, steel, aluminium, etc. Neither engineering employers nor working foundrymen always realised fully what a lot of work there was in the making of a pattern, and in no case was this more so than in making a corebox.

What the Patternmaker Must Know

The patternmaker must anticipate difficulties more than perhaps any other man in foundry practice. The patternmaker must not only be a good craftsman with his hands and his tools, but he must have a knowledge of wood and its quality and peculiarities. He must be able to visualise, before starting, the finish of the pattern in relation to the casting to be made from it. He must know his tools and how to use and sharpen and grind them. He must understand woodturning and how to build up for turning construction, etc. He must be able to appreciate points of construction of the pattern in relation to the design and the method of moulding machine parts. Difficulties of curves and centres, etc., were among the many points which the patternmaker had to control before he actually began the work of construction. In the course of his remarks he said he was not very favourably impressed by machine-made patterns cut out of the solid wood. These, he contended, would not stand hard usage like the skilfully-built-up pattern of the craftsman. Particularly was it noticed that many patterns machine-cut out of the solid had no regard for the fault of grain-edge exposed to all the rough handling the pattern was liable to get in the course of use, and these grain-ends were liable to knock out. Quite often the finish of machine-made patterns was very beautiful, but he suggested that the durability was not there by comparison with the craftsman's production. Furthermore, the solid plate tended to buckle, and this would affect dimensions.

Mr. Copeman said he did not at all like the practice of cutting up a pattern to "make it do." He preferred to build so that a pattern could be altered without damage to it. It was not a big job to reduce or enlarge a pattern by making a core and put on a print. A pattern, however good, once cut, was good no longer. The patternmaker should realise the difficulties of the coremaker and the moulder, and the employer should realise the difficulties of the patternmaker, but the speaker was by no means sure these ideal conditions were as general as they might be. In many cases the drawing office could not enlighten the patternmaker as to how he should meet a situation as required.

DISCUSSION

MR. S. W. WISE (hon. secretary of the Branch), opening discussion and questions, said he could hardly think that, even in the mass-production patternshop, there was so little knowledge of, or regard for, the vagaries of timber as Mr. Copeman's remarks on machine-made patterns rather suggested. Whilst he had the utmost admiration for the skilled craftsman, he must say at once that he had met with some very good machine-made products also.

MR. COPEMAN insisted that it actually was a fact that many machine-made patterns were cut out of the solid, and in doing that one could not avoid the likelihood of getting the grain edges exposed. That was his objection to a machine-made corebox.

MR. G. HALL (Shipley) said he was afraid Mr. Copeman, in a very excellent and interesting address, had issued a sort of mentality challenge to the moulders which was hardly likely to go unanswered in a meeting of that description. It was, of course, all in good part. Quite often a pattern was made correct to design, but without regard to considerations as to whether it would produce a sound casting. Mr. Copeman had in his talk indicated some reasons why that was liable to happen, and had shown how desirable was a closer and more systematic co-operation. There should be in every patternshop at least one man with some personal knowledge of foundry practice, so that patterns would be produced to meet the known problems and difficulties of foundry practised and not merely to reproduce in wood the work of the designer.

MR. CONIBEAR (Leicester), in thanking the Branch for its reception to him as a visitor, said he could agree with much that had been said by Mr. Copeman, but was afraid he could not agree with his rather sweeping condemnation of machine-made patterns.

Smoke from Loom Scrap

MR. J. FEARNSIDE (Keighley) asked leave to break away from the subject of the evening to seek advice as to the best means of preventing excessive smoke from blowing operations when using loom scrap.

The PRESIDENT (Mr. Walker), having ascertained from Mr. Fearnside that the scrap was of a greasy nature, said his place had had the same complaint, but whilst with Mr. Fearnside the complaint was a polite request by a private individual, in their (Mr. Walker's) case they had come up against the official Smoke Inspector. The cure—by definite instruction of the Smoke Inspector—was to clean the grease from the scrap.

The meeting closed with a hearty vote of thanks to Mr. Copeman, on the motion of Mr. S. Carter (Huddersfield), seconded by Mr. W. Fearnside (Keighley).

Books Received

Stock Exchanges, London and Provincial. Ten-Year Record of Prices and Dividends. Compiled and published by E. C. Mathieson & Sons, 16, Copthall Avenue, London, E.C.2. Price 20s.

The greatest utility of this book is for surtax payers at the one end and those who are entitled to income-tax relief at the other, for in both cases the time of payment is important, and this feature is particularly clearly set out in its 585 pages. As there are about eight companies to the page, it can be judged that the survey has covered a particularly wide field.

XUM

Some Factors which Influence Soundness in Non-Ferrous Castings

By ARTHUR LOGAN

(*Concluded from page 348.*)

Experiments on Cubes

As an experiment in gating and running, a series of 6-in. cubes were cast under various conditions. No claim is made that the series is conclusive. They were simply made to test out one or two ideas, and the results (Table I) are merely placed on record as being of interest. The first batch of three were cast to indicate a temperature effect. They were run at the bottom with a gate measuring 2¼ in. by 1 in. These were poured at 1,145 to 1,100 and 1,065 deg. C. respectively. The maximum depth of the top depression and specific gravity of the whole cube are shown in Table I. It will be seen that the density of the lowest—that poured at 1,065 deg. C.—is very satisfactory; in fact, it is actually the best of the whole series made.

FIG. 14.—SIX-INCH CUBE (TABLE I), BOTTOM-RUN.

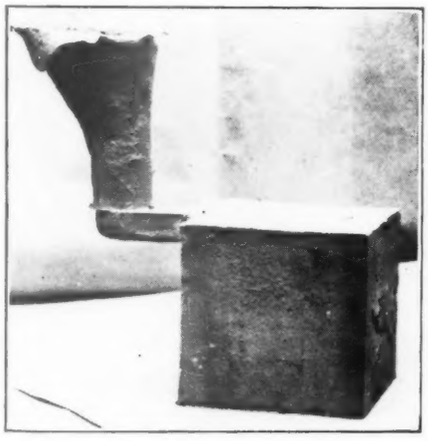

FIG. 15.—SIX-INCH CUBE (TABLE I), TOP-POURED.

The depths of "sink" do not exactly follow the casting temperatures for some reason or other, although, as would be expected, the greatest "sink" occurs with the highest pouring temperature. Nos. 4 and 5 were cast with the same size gate, but run from the top. It was realised that with this size of gate it would not be desirable to exceed 1,100 deg. C., so only the two were cast; one at 1,105 deg. and the other at 1,050 deg. C. In this case, the depth of depression does follow the casting temperature, the hotter poured one having $\frac{1}{16}$ against $\frac{1}{2}$ in. for the one at 1,050 deg. C., but the strange thing is that the specific gravities were practically identical.

Another pair were cast using a very small gate—only 1 in. by ½ in. One was cast without any attempt to feed it, and the other had a 4½-in. diameter head put on the top. When the cube was filled, the runner was stopped off, and the head filled direct from the crucible and rod feeding resorted to. To counteract for the small gate size, the casting temperature was raised to 1,150 deg. C. It was expected that the cube without any feeding would be unsound when sectioned, but such was not the case, the higher temperature apparently compensating fairly well for the small gate. The density was certainly low, however, being only 8.24. Cube No. 7 fed with a rod was very satisfactory, having a "sink" of only ¼ in. and a specific gravity of 8.52, this being the best of the series.

As an example of freak running, another cube was run from the top with a gate only 1 in. by ⅛. This again, in spite of expectations to the contrary, proved to be quite sound when sectioned, the "sink" being $\frac{9}{16}$ and the density

TABLE I.—*Experiments on Six-inch Cubes.*

	Casting Temperature	Poured	Size of Gate	Head	Concavity Area	Concavity Max. Depth	Spec. Gravity	Remarks
	1065°C	Bottom	2¼ x 1	4"	4" Dia	11/16"	8.506	
2	1110°C	Bottom	2¼ x 1	4"	4" x 5"	½"	8.323	
3	1145°C	Bottom	2¼ x 1	4"	4" x 4"	13/16"	8.39	
4	1105°C	Top	2¼ x 1	6	3½" Dia	11/16"	8.344	
5	1050°C	Top	2¼ x 1	6	3" Dia	½"	8.35	
6	1150°C	Bottom	1 x ½	6	4" x 3½"	½"	8.24	
7	1150°C	Bottom	1 x ½	6	5½" x 3½"	¼"	8.52	4½" Dia Head Fed with Rod
8	1150°C	Top	1 x ⅛	6	5" x 5"	9/16"	8.31	
9	1100°C	Bottom	1 x ½	6	4½" x 4½"	5/16"	8.33	4½" Dia Head

8.31. To determine whether rod feeding was really effective in this case, a final cube was cast as nearly as possible the same as No. 7, but without resorting to rod feeding. The temperature unfortunately was 30 deg. lower, but it is not considered that this explains the big difference which was found on comparison. A ring of deep holes was found all round the junction of the head with the top of the cube, and the density was only 8.33. A comparison of this cube with No. 7 fully justifies the use of rod feeding under such circumstances.

The following illustrations show the method of making the cubes:—Fig. 14 shows the bottom-poured set, Nos. 1, 2 and 3; Fig. 15 the top-poured pair, Nos. 4 and 5; Fig. 16 the freak gate cube (No. 8), with a gate of only 1 in. by ⅛ in.; Fig. 17 the freak gate cube, with a close up of head; Fig. 18 the cube (No. 9) with additional head, and Fig. 19 illustrates the sections through tops of the cubes showing the amount of "sink" in each case. In no case was any actual cavity or unsoundness found when the cubes were sectioned.

DISCUSSION

Tired Metal

MR. J. ARNOTT said that, in regard to the question of oxidation during melting, modern practice had demonstrated that oxidising conditions were often preferable and that oxidation was one of the least of the troubles in non-ferrous work and could be overcome. Some of the cases which Mr. Logan had illustrated were not all due entirely to shrinkage. His experience had been that all batches of metal do not behave in the same way. Some gave good results and others gave bad results; neither was casting temperature responsible in all cases, nor was it the sole controlling factor. There came into the picture the question of remelted metal and the difficulties of remelting heads and gates. The trouble was more marked in foundries doing light work; in heavy work there was a lower proportion to be remelted. It was a fact that metal which had been remelted a few times deteriorated in quality, and there was obtained what he called "tired metal." He suggested to Mr. Logan that some of the examples which he had shown were due to that factor. He would have been pleased if Mr. Logan had gone into more of the question of scientific foundry control, as he understood that he had given a considerable amount of attention to the development of such a system of control. He would be glad if Mr. Logan could give some opinions as to the best methods of metal melting. Every week some new melting process came out which was claimed to be superior to any other. Would Mr. Logan give them his own preference for melting methods?

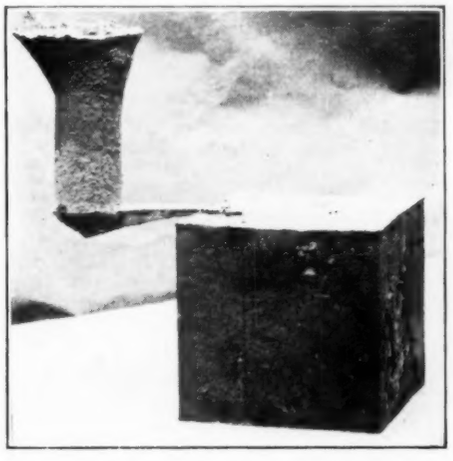

FIG. 16.—SIX-INCH CUBE—FREAK GATED (TABLE I).

FIG. 17.—"CLOSE UP" OF GATE OF BLOCK SHOWN IN FIG. 16.

MR. LOGAN, in reply to Mr. Arnott, said that his references to oxidising melting were quite correct. It had now been shown that reducing conditions during melting gave more trouble and that at the same time the metal could suffer from oxidised metal. The conditions of castings were not always the same; sometimes it was necessary to accumulate large volumes of metal in the

ladle. It was fatal with non-ferrous metals if the ladle was not absolutely dry. In regard to shrinkage, he was prepared to admit that not all the defects were due to change of section, but some of them did certainly show the effect of section. There was a liability to tear from both ends of the scale. Admiralty gunmetal made from virgin metal was liable to tear, and also the same alloy made from metal that had been remelted. In some cases the metal tears because

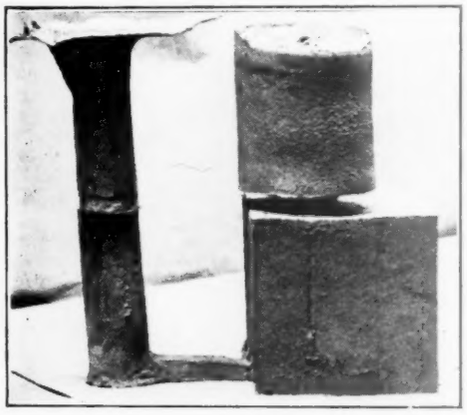

Fig. 18.—Six-inch Cube (Table I) Cast with an Additional Head.

it is too new, and in some because it is too old. He was not prepared to advance any theory to explain it, but he thought that, as Mr. Arnott had mentioned, the metal got tired. In regard to foundry control, he had concentrated largely on casting temperature, as he considered that was largely the control needed in non-ferrous practice. He had instituted an elaborate system of temperature control with very good results. He considered that temperature control was well worth doing. If they kept records and controlled temperatures, they came to a point where a definite

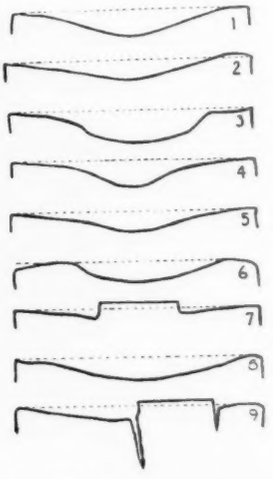

Fig. 19.—Sections through the Tops of the Six-inch Cubes (Table I) showing Resultant Type of Sink.

improvement was obtained. He considered that all the metal in the foundry should be under one control. In respect of melting, he found that different people had different ideas as to what constituted a perfect method of melting. Personally, he thought that it would be hard to beat the crucible for speed of melting, but he had no very definite preference, and at the moment that matter was being investigated by him.

Mr. McCulloch said that he took particular notice of one of the slides, and asked what size of feeding head and gate Mr. Logan used. Also, he would like to know whether he used skim gates or drop gates.

Mr. Logan replied that he took it Mr. McCulloch meant the cubes. The bottom gates were 2¼ in. by 1 in. and the top gates the same size. The freak gate was 1 in. by ⅛ in., which was very small. In the other experiment the bottom gate was 1 in. by ¼ in., with feeding head. In one case rod feeding was adopted, and in the other not. In runner gates of large size it was necessary to use a strainer core to keep the runner filled. Skim gates were not used—only the core.

Mr. Morehead said that he had experienced two little difficulties which had not been mentioned by the author. In making the 65/25 alloy with 5 per cent. lead and 5 per cent. zinc he had found a quantity of finely-distributed hard, dusty material. In naval brass he had experienced skin folding, due to an oxide skin. In a cylindrical casting the top edge in the length of the casting had what was apparently a crack, but was really just a skin defect. There was no doubt that certain trouble, whether they called it oxidation or not, such as metal spewing out of the top of the runner, was generally overcome by deoxidation.

Mr. Logan, in reply, said that he had not experienced the hard spots referred to by Mr. Morehead. They might get it with tin oxide formed during melting. In regard to the skin folding, he had no theory to put forward, and could not offer an opinion without seeing the casting. The trouble might be due to the use of a damp ladle. He had experience of that; the metal poured satisfactorily, and shortly after pouring came up to the top of the runner. The casting was very holed and showed a lot of tin sweat. Metal reduced by hydrogen gave a gas evolution in a very severe form.

The Iodine Method for the Determination of Oxides in Steel

(*Concluded from page* 364.)

As a rule 7 to 8 grms. of millings are used for a determination and 5 to 20 mg. of residue are obtained. The complete examination of these small amounts is still being investigated. Bannister recommended colorimetric methods, but these have not been found satisfactory for traces of alumina. The estimation of small amounts of silica in the presence of relatively large amounts of iron oxide by the hydrofluoric-acid method is not satisfactory. Fusion of the residue with sodium carbonate has also been used, but trouble has been experienced owing to attack of the platinum crucible during the fusion.

In more recent work the residue is digested with concentrated hydrochloric acid. The insoluble portion is filtered off, ignited and weighed. Silica is determined by evaporation with hydrofluoric and sulphuric acids, and the small residue remaining is fused with a little sodium carbonate; the melt is dissolved in hydrochloric acid and added to the main filtrate. Iron is determined by means of the "cupferron" reagent, alumina by means of ammonium benzoate and manganese with bromine and ammonia. As in some cases the weight of the precipitate obtained is very small, careful weighing is necessary and the use of a micro-balance is practically essential.

In Table I, results for the total residue obtained are given for a number of steels, using a "Cella" and a No. 50 Whatman filter.

In Table II some examples are given of analyses of the residues which illustrate the necessity for careful weighing.

Metal Exchange Activity

By "Onlooker."

In marked contrast to spells of dullness which have from time to time obtained in Whittington Avenue, conditions on the London Metal Exchange have recently been very active, and the midday sessions present a picture of very lively interchange of bargaining from start to finish. In expectation of the curtailment pact in copper, trading in the standard copper ring began to pick up early in the year, and from January to May there has been a turnover in warrants of not much less than a quarter of a million tons, and that in a five-day week, during which only about half an hour daily is devoted to copper in the morning and afternoon sessions together. Copper has really been a most satisfactory market, full of life and providing ample and continuous opportunity to the manufacturer, merchant and producer to hedge against his holding of metal. From time to time the spread between electrolytic and standard has shown an inclination to widen, but this tendency has not developed very far and the variation in the margin has never been sufficient to upset calculations.

In direct contrast to copper, conditions in the tin market are extremely unsatisfactory, for the artificial squeeze for nearby metal, due to the high-handed attitude adopted by the Pool, has resulted in the establishment of a backwardation varying between £5 and £6. This preposterous premium on the early position makes it impossible for any trader holding tin to hedge against it satisfactorily, and in fact the risk of loss involved in operating on such a market is decidedly greater than taking a chance on purchases by leaving them unprotected. Had the Import Duties Advisory Committee been given a task in regard to tin similar to that which they have been investigating in lead and spelter, there can be little doubt that drastic measures would have been taken to end a state of affairs which has virtually killed trading in tin on the London Metal Exchange. The whole pith and essence of the London market is that business should be conducted on free and untrammelled lines. At the present juncture the position in tin gives the lie to this, and there is a growing feeling of acute annoyance that nothing has been done by the authorities to end this unhappy state of affairs.

From time to time the London Metal Exchange is criticised on account of speculative activity, and it is pointed out that a large proportion of the daily turnover comes as a result of orders transmitted to brokers by people who have no interest in metals from a business point of view. This statement is doubtless true, but critics speak and write as if the whole Exchange were in the grip of the speculator, with Whittington Avenue transformed in consequence into a kind of glorified gambling hell! This idea is, of course, quite erroneous. Let us consider for a moment the position in copper. That much of the buying during the past two months has been speculative or semi-speculative in character cannot be denied, but it takes two to make a bargain, and if speculators have been among the purchasers, producers and other legitimate trade interests have sold to them, such sales being backed by holdings of metal.

For a time price movements on the Metal Exchange may be exaggerated by the activity of the speculator, but all he can do is to accelerate the pace over a period, before eventually he is compelled to drop out, not infrequently a sadder but a wiser man! In comparing the relative values to the trading community of speculation and stranglehold, the former wins every time. Look at the position in tin!

XUM

Present-Day Practice and Problems of Welding in the Engineering Industries

SUMMARY OF PAPERS (Group I) TO SYMPOSIUM ORGANISED BY THE IRON AND STEEL INSTITUTE

The Symposium on the Welding of Iron and Steel organised by the Iron and Steel Institute, and held during the annual meeting in London, was sub-divided into groups, Group 1 dealing with "Present-Day Practice and Problems of Welding in the Engineering Industries." Numerous Papers were presented to each group, and those in Group 1 (*b*) were summarised by PROF. B. P. HAIGH. We append extracts from this summary.

PROF. HAIGH said that 27 Papers had been presented for discussion at that session. Interest, he said, centred round the arc welding of mild-steel plates, but it extended also to forgings and castings, and on the one hand to wrought iron and on the other to high-tensile steels, and even to cast iron in certain applications. It was significant, he thought, that the first Paper in the series should deal with an industry and a process which was older than written history. He referred to Mr. Fletcher's Paper dealing with the production of wrought iron by puddling.

Repair Work

That was essentially a welding process, but it was a process which, as he said, was older than written history. It was clear that the development of welding was not yet complete. It had only come to the end of about the first three decades of its existence, and a very great deal remained to be accomplished. It was of interest to find that a number of the Papers—those by Brett, Pearson, Faulkner and Roberts—dealt with repair work and with the reclamation of faulty castings in steel or grey cast iron. In the early development of electric welding, repair work provided a field for immediate economic success. The field of repair work was of tremendous importance for the young and growing art, and economic success was found there. As a result of that field being developed in the early days, there were two enduring consequences which had great influence upon the later development of welding. In the first place, as reflected in the Papers to which he had referred, wide circles of customers gained confidence in the process, and that confidence rendered it possible to go ahead. It was true, of course, that there were many difficulties, many breakdowns, but the feeling of confidence was built up. In the second place, a relatively small number of operators gained skill and extraordinary experience. They gained those qualities under conditions of the most varied character

Mr. Brett, referring almost wholly to repair work, had given an interesting account of the varied difficulties. It was of tremendous importance that faults of design could be eliminated. When a repair was carried out by electric welding it afforded an invaluable opportunity for altering the design, and, if the design were altered, as it often should be, one would find clear traces of the repair left, so that those who passed by might learn a lesson. Many valuable lessons had in fact been learned in that way.

Repair work required training and observation, and observation in wide fields of practice. It was a difficult thing for the welding operator, and even for the welding foreman, to get that experience in wide fields of practice. It required an understanding of what the part was required to do as well as a knowledge of welding. He thought there was in that work a wide field for practical research, and an indication of the necessity for broader education for those who were going to plan welding repairs. Brett and Faulkner, both speaking of repair work, indicated the importance of heating the parts before welding. Why in many cases was it necessary to heat the parts which one was going to weld together? If the answer to that question could be written down clearly, so as to form the science of the subject of heating, he thought it would be invaluable to many people engaged in new construction as well as in repair work.

Temperature Control During Cooling

The importance of temperature control during the cooling of the weld was recognised clearly by several authors, particularly in relation to repair work, but he thought that that also had not yet had the scientific attention which it merited. One was accustomed to speak of electric, oxy-acetylene and water-gas welding, and when one did so, one used those adjectives to specify the means of producing the heat required. It was rather remarkable, however, that no such adjectives were used to direct attention to the conditions of cooling, which, in all probability, more directly governed the mode of crystallisation, and, therefore, the mechanical strength and the ductility of the deposit. He felt, therefore, that a good deal of attention might well be directed to cooling, and that adjectives might be used to explain how one was counting on the heat going out of the weld into the surrounding parts.

He had tried before now to put the matter forward in this way; one had the electrode and one had the job which was to be welded. How was it that the metal in the electrode knew that it was expected to go down and deposit itself on the job? How was it, on the other hand, that the metal in the job did not make up its mind to evaporate and fly up and make an electrode, so that the electrode would get longer and longer instead of shorter and shorter? He hoped he would be forgiven for putting such simple questions. There was, of course, a perfectly simple scientific answer. The heat might be produced equally by alternating current in the two parts, the electrode and the job, but the metal could go only in one direction, because the job could get rid of the heat. The metal condensed and solidified because heat was taken away. The weight of metal deposited was proportional to the amount of heat taken away. It was necessary to absorb the latent heat, and he thought attention might well be given, as it was given in many of the Papers, to the question of how to draw away the heat and get the metal to condense where it was wanted. The heat must be taken away from the place where it was desired that the metal should go.

Formation of Cracks

The formation of cracks in the deposit was discussed by several authors, and particularly by Roberts, with reference to the reclamation of massive steel castings, but what was contained in those Papers had a much wider field of application. The temperature range in cooling was naturally and inevitably so great that the successive runs in every electric weld deposited on thick cold metal were presumably self-strained in a plastic manner continuously during cooling. It was difficult to recognise that, but the more one thought of it the clearer it became that every particle of weld deposit put down contracted so much that it was necessarily brought up to its yield point before the weld was finished. When the runs were thin enough, and free from "hot shortness," no harm resulted from the deposit being stressed up to the yield point; on the contrary, the metal must be beneficially hardened. The production of dangerous temperature gradients and thermal stresses appeared to require further investigation, both by experiment in a practical way and by mathematical analysis. He was rather impressed and disappointed by the absence of mathematical analysis in the large body of material contributed to the symposium; it represented, he thought, rather a pessimistic outlook that so few authors had ventured to try to make their ideas still clearer by quoting a formula.

The subject of cooling and cracking was one which lent itself to mathematical expression, and the practical importance of the term $E\alpha$ (which for steel was about 1 ton per sq. in. per 7 deg. C.) should be taught in every university and technical college. The term $1 - \delta$ (Poisson's ratio) and $1 - 2\delta$, which had to be used in mathematical analysis in conjunction with $E\alpha$, were of even greater practical importance, and he thought they ought to be more generally familiar in relation to cooling stresses.

When a mass of metal cooled rapidly, in the circumstances pictured by Roberts, and the exterior became cold, hard and rigid while the interior was still hot, further cooling of the interior produced internal contraction, and, as a consequence, tension acting more or less equally in all directions without shear stresses such as tended to cause plastic strain. This was not the time to develop the theory which was based on that picture, but the development was of a great deal of interest. He did not see it touched on in any of the Papers submitted, and that was perhaps an omission.

In spite of the success attained in repair work, the use of welding in the reclamation of faulty castings was long regarded as improper; and that attitude might still be justified, as the process of welding provided a means, unfortunately, of covering faults as well as of repairing them. If reclamation was now permitted, this sign of increasing confidence might be welcomed and appreciated as a high tribute to honest capacity for taking pains. If he might say so, he thought that electrodes for purposes of reclamation and for other purposes also should be selected not wholly for technical excellence as revealed by test figures on samples, but also to facilitate reliable work by men of character who deserved every opportunity which could be given to them to control the arc and to control the flow of molten slag on the surface of the metal. One ought not to judge wholly by test figures on samples of tensile strength or fatigue strength; one ought to judge by looking at the job as it was carried out to see which electrodes gave the operator an opportunity to do what he was trying to do. He felt sure that one of the greatest difficulties in electric welding to-day was to discover a sufficient number of men to carry out the orders which were forthcoming. The education would have to include not only technical and vocational education, development of skill, but be of that wider type which gave a man an honest pride in taking pains.

Welding in Constructional Work

Several Papers dealt with the construction—turning now to new construction—of massive weldings in lieu of castings or forgings for the mechanical and electrical engineering industries. It was notable that substantial arc-welds were now commonly called upon to stand tensile and shear stresses as severe as could be transmitted to them by mild-steel plates of good quality, and it was reassuring to know that when such joints were tested to the yield point under critical conditions in the laboratory, the plates and rolled sections in almost every case suffered severely before the welds revealed any sign of injury at all. One of the many interesting features in a

Paper by Griffin, describing an electrically-welded mobile crane for heavy duty, was an illustration of the results caused by a collision. No weld fractured, although the members suffered calamitous distortion.

In recent years much ingenuity had been directed to arranging large and important weldings in special ways, such that the points should be free from severe tensile stresses, but it was believed that general experience as well as laboratory investigations indicated that no such inconvenient restrictions were really necessary. He thought that was a very important point. Were we to advance by freeing the weld from its duties, or were we to advance more boldly by placing those heavy duties on the weld? The Papers indicated many examples in which the most severe tensile stresses had been imposed on arc welds, and he thought they indicated no unreasonable danger in following that policy. That was a most important matter; we had arrived at, or perhaps had recently passed, that very important division of the ways of progress.

Arc-Welded Fan Wheels

The results of ten years' experience with arc-welded fan wheels were discussed by Zeriali. That application was of special interest on account of the success attained in circumstances involving high centrifugal stresses associated in many cases, though not always, with severe vibration. Mr. Zeriali showed photographs of fan wheels which had been destroyed, doubtless by accident, and it was significant that the welds in those wheels had not broken; on the contrary, the mild-steel parts had been distorted into almost unrecognisable shapes, but the welds remained intact. That was the kind of weld which most people hoped to produce. The fan wheels appealed to him particularly, because of the very severe tensile stresses associated with vibration. Whatever might be the results of tests, and it must be admitted that many test figures gave reason for anxiety, the facts showed that tensile stresses and vibration could be met by joints in which the deposit had been reasonably generously proportioned.

The construction of gear wheels by arc welding, described by Moore and Swindell, must have been undertaken, he believed, with special hopes, because in the gear wheel, as the authors pointed out, there was great advantage to be gained by making the rim of the wheel of one quality of steel and the spokes and the boss of other qualities.

There was a great field for the joining together of different materials, not only in gear wheels but in other cases also. In the case of gear wheels there were self-evident advantages in construction by welding, but there was reason for special anxiety also, because of the severe local stresses and the severe local changes of stress which occurred in the spokes and the junctions of the spokes when the rim of the wheel passed under the pinion. Those stresses and changes of stress were probably far more severe than could be either calculated or measured, unless perhaps by the methods which Prof. Coker had developed so skilfully. Warping, moreover, if it had been present, would have been a cause of special difficulty, if it had changed gradually after the teeth had been cut.

Question of Warping

The Papers contained numerous examples of methods of dealing with warping, and he hoped that that point, which was of an essentially practical nature, would give rise to a good discussion. It was evident that individual cases would long continue and must long continue to require individual consideration. The sequence of assembly required careful study, and an example of considerable interest was given by Bavister in his Paper on automobile applications. Warping, when it was evident, most commonly occurred immediately during cooling, and, in the case of many weldings used in machinery, was eliminated during subsequent machining operations. In more severe cases, however, further warping might develop gradually afterwards during machining or in subsequent service. The successes attained in the construction of stators and rotors for electrical machinery, described by Davies, by Dorrat, and by Hawkins and Donkin, were therefore especially interesting in that they gave an indication of the methods used to overcome warping.

Special Advantages of Weldings

Weldings offered special advantages for bedplates and foundations for engines and other heavy machinery. In one category were the savings which resulted from the elimination of patternmaking and the misuse of metal to facilitate sound casting, and in another category were the savings which resulted from the higher strength and particularly from the higher modulus of elasticity of mild steel. Mild steel, weight for weight, was much stiffer than cast iron, and, as bedplate and foundation columns were often required to give stiffness much more than strength, he thought welding was going to play, and was already playing, a very serviceable part in that connection. In a third category were the savings that resulted from improved functional design.

Mr. Spanner had called attention to the progress of arc welding in marine engineering and shipbuilding, and to the special conditions of marine service, which must be very well known to those who were engaged in marine service but which were probably not appreciated by others. It was encouraging to reflect that in the application of welding processes to shipbuilding, this country had been continuously active from the start, and was still, he believed, pre-eminent. Not only in new construction and in repair yards, but also in repairs necessarily carried out under adverse conditions at sea, arc welding should be invaluable to the marine engineer. He looked forward to the time when ships would more commonly than at present carry the few additional auxiliaries required to enable them to carry out simple but essential repairs at sea. Mr. Spanner also pointed out how very isolated a ship was once she had left port. She might keep up communication with the shore by radio, but if a breakdown occurred it was primarily on themselves that those at sea must depend. Personally, he believed a simple arc-welding equipment would often carry them through where at present great delays occurred. At Greenwich, a boiler plate, holed in action many years ago and patched while the vessel remained exposed to enemy fire, was preserved as an example in a museum, and in recent years he had often reflected that that gallant vessel would have fulfilled her mission even more promptly if arc-welding plant had been available on board.

Automatic Welding

Automatic welding by different processes was discussed by Carpenter and Guest, and in many of its applications by other authors. Chain production by different methods of resistance welding was discussed by Holden, who indicated that chains up to 2 in. and perhaps even up to 3 in. could be welded successfully and economically by the resistance process, and was discussed also by Napravnik and Popov, who indicated in a very interesting manner that steel offered advantages over wrought iron for these modern methods of welding. For those who learned how to weld 30 years ago, and learned that wrought iron could be welded and steel could not, such a conclusion seemed a reversal of all they had been taught, and the significance and basis of that remark were worthy of careful attention. Chain welding as well as other examples of welding in mine haulage gear were discussed by Prof. Andrew and Mr. Johnson.

Welding in Automobile Construction

In relation to automobile construction, resistance welding was discussed by Arrowsmith, by Bavister, and in a Paper by Daley. The special plant which was used in automobile construction for repetition work presented features of great interest. The rapidity of action required in spot-welding had not only been obtained automatically with success, but seemed to be very necessary for the metallurgical results; and he thought that the assurances given by several authors indicated that one might expect to see resistance processes applied in the future to plates and sections of much greater thickness than had been customary in the recent past. Development on those lines would be looked forward to with a great deal of interest.

Welding of High-Tensile Steels

The welding of high-tensile steels was discussed, in relation to aircraft construction in particular, by Sutton and by J. B. Johnson, and further Papers on that subject from Roosenschoon and Taylor were anticipated. It was notable that certain high-tensile steels welded readily with complete success, and it would be interesting to hear where the margin of the qualification "certain high-tensile steels" lay to-day. The welding of high-tensile steels presented a problem of infinite variety, because of the variety of the steels themselves, and it would be unreasonable to expect that any sudden change would make all of them equally easy to weld. This was a process in which the situation was going to change from day to day, and he hoped the discussion would indicate the present position. Other processes of welding such as atomic-hydrogen welding, were dealt with by Carpenter and Guest and by Johnson, as well as by other authors, and he hoped that practical experience with regard to these also would be forthcoming.

"S" Monel Metal

A new development in corrosion-resistant castings has been announced by the Bayonne Foundry of The International Nickel Company. This is the production of a new material to meet special purposes.

Known as "S" Monel, this material is somewhat similar in analysis to regular Monel metal, the essential difference being in silicon content, which is raised to a maximum of 3.75 per cent. In properties it has a higher hardness than the regular grade of Monel metal and greater resistance to wear and erosion, particularly steam erosion. Of outstanding importance is the fact that it is non-galling, especially at high temperatures. The as-cast material can be machined without difficulty if the hardness is held at 325 Brinell by limiting the silicon to 3 per cent. The harder grades must be softened for machining and later rehardened by heat treatment. Its unique physical properties are indicated by the following:—The physical properties of "S" Monel are as follow (approx.): Tensile strength, 45 to 50 tons per sq. in.; yield point, 40 to 44 tons per sq. in.; elongation on 2 in., 2 to 5 per cent.; reduction of area, 2 to 5 per cent.; Brinell hardness, 275 to 350.

Another grade of Monel metal developed coincidentally, has an intermediate hardness of about 225 to 250 Brinell. Its chief advantage is a higher ductility than "S," though it is not as outstanding in antigalling qualities. Its silicon content is approximately 2.50 per cent.—"American Metal Market."

The Last Swiss Blast Furnace

The report for 1934 of the Rollsche Eisenwerke, at Gerlafingen, shows that trading losses continue to be sustained, while the exhaustion of the local iron-ore deposits and bad trade have led to the closing down of the blast furnace, the last one working in Switzerland. In view of the high-wages and current market prices, there is little likelihood of the furnace being restarted, which therefore heralds the complete suspension of the Swiss iron-making industry.

XUM

ALUMINIUM ALLOY

Recommended for Pistons and similar work

BA *The* **BRITISH ALUMINIUM** *Co., Ltd.*

Head Office: ADELAIDE HOUSE, KING WILLIAM STREET, LONDON, E.C.4

Telephone: MANSION HOUSE 5561 & 8074 (5 LINES). *Telegrams:* CRYOLITE, BILGATE, LONDON

LONDON WAREHOUSE: 25-29, Pancras Road, N.W.1. | BIRMINGHAM, 4: Lawley Street. | MANCHESTER: 274, Deansgate. | LEEDS, 3: 66, Kirkstall Road. | NEWCASTLE-ON-TYNE, 1: Milburn House. | GLASGOW, C.2: 113, West Regent Street.

F.T.J. 30.5.35

ESCOL

ENAMELS

WE DO NOT BELIEVE IN THE DOCTRINE OF "SALES REGARDLESS"

It is comparatively easy to sell by extravagant claims, but we will CONTINUE to sell Escol Enamels on merit only

WE SUPPLY PROVED EQUIPMENT AND REQUISITES COVERING EVERY REQUIREMENT OF THE

VITREOUS ENAMELLER!!!

J. GRAY & SONS LTD.,

Enamelling Engineers,

5, VICTORIA STREET, LONDON, S.W.1

Telephone: VICtoria 5794. Telegrams: "Grayasons, Sowest, London."

Sole Manufacturers of Escol Enamels:—J. F. Stewart & Co., Ltd., Paisley Works, Swain's Road, Tooting, London, S.W. 17.

This Week's News in Brief

Trade Talk

Messrs. Hurst Nelson & Company, Limited, Motherwell, have received an order for 12 underframes and bogies from the Junakad State Railways, India.

Messrs. Drysdale & Company, Limited, Bon Accord Works, Yoker, Glasgow, are to supply, deliver and erect two main sewage-pumping units for the Cardiff Corporation.

The Sixth International Congress for Scientific Management is to be opened by its patron, H.R.H. the Prince of Wales, in the Central Hall, Westminster, on July 15.

The twelfth annual general meeting of the Institute of Welding will be held in the hall of the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, on Monday, June 3, at 3.30 p.m.

The directors of the Park Gate Iron & Steel Company, Limited, Rotherham, have decided to undertake a scheme of further development of the works, which will take about three years to complete. Last year's ingot output of the works was a record.

Members of the Sheffield Society of Engineers and Metallurgists paid a visit recently to the works of the Sheepbridge Coal & Iron Company, Limited, and the establishment of the Sheepbridge-Stokes Centrifugal Casting Company, Limited.

The London & North Eastern Railway Company has placed orders with the Birmingham Railway Carriage & Wagon Company, Limited, for 25 vestibuled carriages, and with the Metropolitan-Cammell Carriage & Wagon Company, Limited, also for 25 vestibuled carriages.

The sites of the Old Phœnix and Clifton Ironworks at Coatbridge, which have been derelict for many years, have been purchased by Mr. James N. Connell, steel merchant, Old Dundyvan Foundry. The ground purchased extends to about six acres, and will be used for extensions to the Old Dundyvan Foundry.

Nearly 100 members of the Manchester Association of Engineers visited the Irlam works of the Lancashire Steel Corporation, Limited, on Tuesday, May 21, and made a round of inspection of the coke ovens, blast furnaces, steel plant, rolling mills, and foundries. They were accompanied by Mr. John A. Thornton, general manager, this year's President of the Association.

The secretaries of the Scottish Manufactured Iron Trades Conciliation and Arbitration Board have been informed by Mr. William F. Andrew, C.A., Glasgow, that he has examined the employers' books for March and April, 1935, and certifies that the average net selling price brought out is £9 8s. 9.22d. This means that there will be no change in the wages of the workmen.

Renishaw Iron Company, Limited, manufacturers of the well-known brand of "Renishaw Iron," are exhibiting at the British Industries Fair various qualities of pig-iron they produce, with a range of castings and mechanical tests produced from them. An item of particular interest to many is a scale model of a blast furnace which Ashmore, Benson, Pease & Company, Limited, made and erected for the South African Steel Corporation, Pretoria.

Messrs. G. & J. Weir, Cathcart, Glasgow, will shortly begin production of an airplane engine that is expected to revolutionise flying. The firm began experimenting some years ago with an engine designed for light aircraft, to which the name of "W.2" was given. The engine immediately secured success and recognition for its lightness and dependability. Experiments were continued at the firm's Holm Foundry, and further refinements have made possible the production of engine types "W.3" and "W.4."

During the Free State Budget debate in the Free State Legislature, the Minister for Finance was taken to task over the duty imposed on steel windows, Mr. Belton, an Opposition Deputy, stating that these were not made in sufficient quantities in the country to warrant the new impost. To a further protest by the same Deputy regarding the 75 per cent. duty imposed on copper tubing used in building, the Minister revealed that a factory for the manufacture of this class of tubing was in existence, but it had not started production yet. Other iron and steel duties came in for severe criticism.

Financing New Cardiff Steelworks

An issue at par of £2,250,000 4 per cent. first mortgage debenture stock is being made by the British (Guest Keen Baldwins) Iron & Steel Company, Limited. The issue is part of an authorised amount of £2,500,000 stock, the balance of £250,000 being reserved to be deposited, if necessary, as collateral security for overdrafts and temporary loans which the company may from time to time obtain from its bankers in the ordinary course of business. The company was incorporated in 1930 to effect an amalgamation of the heavy iron and steel business of Guest, Keen & Nettlefolds, Limited, and Baldwins, Limited. The assets taken over comprised principally limestone quarries, coke ovens, blast furnaces, steel plant, heavy and light plate and bar rolling mills at Margam, Port Talbot, Cardiff and Dowlais, and the entire share capital of the Briton Ferry Works, Limited, Dowlais Collieries, Limited, and Cribbwr Fawr Collieries, Limited. Since its formation the company has pursued a policy of increasing operating efficiency and reducing manufacturing costs by the concentration of output at fewer units, and by a general improvement of the equipment taken over at the inception of the company, on which an amount in excess of £500,000 has been spent. As a result of the policy of concentration of output, the works at Dowlais are now redundant, whilst the steel plant and rolling mills at Cardiff have been dismantled for the purpose of construction of new plant. The principal products manufactured by the company are pig-iron, steel ingots, rails, fishplates, sleepers, sections, boiler plates, ship plates, billets and colliery rails and arches. Mainly with the object of manufacturing semi-finished steel in the shape of billets and sheet bars, the company is now engaged on the construction of a large new steel plant and rolling mills on an 83-acre site at Cardiff. There is already on the site a modern blast-furnace plant, the capacity of which is being enlarged. Two batteries of coke ovens are also being erected. The greater part of the constructional work of the new plant will be completed by December 31, 1935, and it is anticipated that the plant will be in substantial production early in 1936. The total estimated cost of the new works at Cardiff is £2,700,000. The net proceeds of the present issue are estimated at £2,176,800, and the two parent companies have entered into undertakings to provide as required, in proportion to their respective interests, any balance needed to complete the construction in so far as not provided by the company out of its own resources.

Contracts Open

India, June 24.—Locomotives and boilers, for the Eastern Bengal Railway. The Department of Overseas Trade. (Reference G.Y. 15,151.)

Long Eaton, June 15.—For the Urban District Council:—Contract No. 1.—Supply and delivery of about 7,300 yds. of 10-in. cast-iron pipes, with appurtenant specials. Mr. H. Raven, engineer and surveyor, Town Hall, Long Eaton. (Fee £3 3s., returnable.)

Plympton St. Mary, June 6.—Providing and laying about 5,240 yds. of 3-in. dia. cast-iron water mains, and about 3,683 yds. of 4-in. and 3-in. dia. cast-iron water mains, and other works, for the Rural District Council. The Engineer, Council Offices, Plympton. (Fee £2 2s., returnable.)

Cowes, June 1.—One mild-steel high-class dish-ended Cornish boiler, 18 ft. long and 5 ft. 6 in. dia., working pressure of 120 lbs. per sq. in., for the Urban District Council Gas Department, boiler to be complete with forced draft breeze-burning furnace. Mr. R. A. Gretton, engineer and manager, Gasworks, Cowes.

Stockport, June 17.—In connection with the Goyt Valley water supply, for the Town Council:—Contract No. 9—supply of either (*a*) cast-iron pipes and specials or (*b*) steel pipes with some cast-iron specials, for the following trunk mains, *i.e.*,—(1) Pipes, 21 in. dia., 3,200 lineal yds.; (2) pipes, 18 in. dia., 18,700 lineal yds.; (3) pipes, 15 in. dia., 6,600 lineal yds.; with some miscellaneous pipes from 30 in. down to 4 in. diam. Mr. G. H. Hill & Sons (Manchester) 40, Kennedy Street, Manchester. (Fee £3 3s., returnable.)

Personal

Dr. Oscar Faber has been elected President of the Institution of Structural Engineers for the session 1935-36.

Mr. D. Fisher, managing director of the West Lothian Steel Foundry Company, Limited, has been appointed a magistrate of the burgh of Bathgate. In his early life Mr. Fisher was one of the firm of Messrs. Renton & Fisher, Limited, steelfounders.

Dr. L. B. Tuckerman, Assistant Chief, Division of Mechanics and Sound, and Principal Scientist, American National Bureau of Standards, will deliver the Tenth Edgar Marburg Lecture at the annual meeting of the American Society for Testing Materials on June 24 to 28, in Detroit.

Mr. George Langlands, formerly general manager at the Marine Engine Works, Dalmuir, of Messrs. William Beardmore & Company, Limited, has been appointed general manager under Mr. James Gilchrist at Messrs. Barclay, Curle & Company's North British Engine Works, Whiteinch.

Lord Weir, who is to act as adviser to the Government in their air industry expansion programme, is chairman of the Clydeside engineering firm of G. & J. Weir, Limited. He is also a director of Imperial Chemical Industries, Limited, and the International Nickel Company of Canada, Limited.

Mr. H. A. McColl, lecturer in metallurgy at Bradford Technical College, and a popular personality in the activities of West Riding of Yorkshire Branch of the Institute of British Foundrymen, was the chief organiser of the Bradford College students' annual "rag" on May 18, which raised over £1,100 for the hospitals. Before coming to Bradford as a metallurgical instructor, Mr. McColl was for five years a member of the Manchester University "Rag" Committee.

Will

Salkeld, William, formerly analytical chemist at Carnforth Ironworks ... £24,564

Notes from the Branches

Lancashire Branch.—A varied programme of Lancashire Branch activities, during the last few weeks, has included a joint visit by the Burnley Section and the Junior Section (Manchester) to the works of the Lancashire Steel Corporation at Irlam, and the 60 members who participated enjoyed an interesting afternoon on Saturday, May 18. On Friday, May 24, the annual examination for the "John Wilkinson" Memorial Medal was held, and 10 Junior Section members competed for this award. Mr. W. Holland (President of the Section) and Mr. J. E. Cooke (hon. sec. Lancs Branch) presided over the examination.

On Saturday, May 25, by courtesy of Messrs. Howard & Bullough, 120 members visited Accrington and were conducted on a comprehensive tour of the works and foundries of the company. At the conclusion of tea Mr. J. Hogg (Senior Vice-President) proposed a vote of thanks to the directors and to Mr. J. Jackson (Branch President) who was acting as host on their behalf. Mr. R. A. Jones (Junior Vice-President) seconded the proposition which was carried with enthusiasm. In responding, Mr. Jackson thanked the members for their support, and expressed the gratification of the company at the considerable amount of appreciation expressed by the visitors. He felt that the ever-increasing interest of members in all Branch activities betokened a very healthy state of affairs, and the presence and keenness of a large number of young members was a factor which indicated a successful future in Branch affairs. He extended a very hearty invitation to members, their ladies and other friends of the Institute to be present on the annual picnic to Kirkby Lonsdale on Saturday, June 1, mentioning that coaches would start from Manchester, Accrington and Burnley.

Holidays in

Unparalleled SOMERSET

Somerset is unique. Its coastline is not of the longest nor its acreage the greatest, but within its confines are situated such inimitable features as Cheddar Gorge; the wonderful caves at Cheddar and Wookey; Burrington Combe; the Mendip and Quantock Hills; seaside resorts such as Minehead, Burnham, Weston-super-Mare and Clevedon; and a host of interesting towns and old-world villages with their setting of rural beauty, every mile of which is dignified by memorials of the valour, wisdom and piety of the mighty past. To know Somerset is to love it.

ROMAN BATHS, BATH

BEFORE YOU GO

Two books that will tell you all about Somerset and the accommodation it affords:

"SOMERSET" by Maxwell Fraser, F.R.G.S. (price 1/- paper cover, 2/6 bound in cloth).

"HOLIDAY HAUNTS" 1935, containing Holiday Addresses, Photographs, &c. (price 6d.).

HOW YOU GET THERE

"Monthly Return" Tickets at about 1d. a mile 3rd, or 1½d. a mile 1st Class are issued from nearly all stations.

WHEN YOU GET THERE

1st and 3rd Class Weekly Holiday Season Tickets, at exceptionally cheap rates, will enable you to see the best of the county.

All information will gladly be supplied by the Superintendent of the Line, Great Western Railway, Paddington Station, London, W.2, or can be obtained at any Railway Station or the usual Tourist Agencies.

GWR

Raw Material Markets

Reports from the producing areas continue to be favourable. Demand for pig-iron is maintained. Stocks still exist at the furnaces, but they are drawn upon from time to time, and the current output is going away steadily. More active conditions in some sections of the foundry industry promise an increased demand, but it is unlikely that the ironmasters will be required to put more furnaces in blast, at least for the time being. Steady deliveries of semi-finished steel are being called for, but most consumers are covered ahead, so that current business is restricted. The manufactured iron and steel departments are still busy, and orders in hand should maintain activity on the present level for some time ahead.

Pig-Iron

MIDDLESBROUGH.—Production of foundry iron in this area is on a comparatively small scale. Only two furnaces are producing foundry numbers, and their output is readily absorbed, while stocks have fallen to a level lower, probably, than in any previous period of normal trade. Activity in pig-iron is most marked in those grades used for steel-making. Output of basic iron is on a large scale, and mostly goes into production on the spot. Prices for the home market are unchanged. The standard No. 3 Cleveland G.M.B. foundry grade is quoted at 67s. 6d. per ton delivered Middlesbrough, 69s. 6d. delivered Durham and Northumberland, 67s. 3d. delivered Falkirk and 70s. 3d. delivered Glasgow. In the case of No. 1 foundry iron, 2s. 6d. per ton extra is charged, while No. 4 foundry and No. 4 forge irons are quoted at 1s. per ton less than No. 3. Export business remains restricted, and is only obtainable at a sacrifice in prices.

East Coast hematite remains a firm market and production is being fairly readily absorbed. There are still stocks in hand. The fixed zone prices are universally quoted, No. 1 East Coast hematite being 69s. per ton delivered Middlesbrough, 71s. delivered North-East Coast, 75s. delivered Scotland, 76s. delivered Lancashire, 75s. to 78s. delivered Yorkshire and 79s. delivered Birmingham. For export No. 1 hematite is quoted at around 63s. 6d. per ton.

LANCASHIRE.—Consumers of Midland brands of foundry iron continue to take deliveries on a good scale, but still are not disposed to book very far ahead, the stable price position being the chief factor in this connection. Prospects of the consuming industries are reasonably good. Textile machinists are taking regular deliveries and sales to jobbing foundries and to the heavy electrical and other engineering industries account for a considerable tonnage in the aggregate. The light-castings foundries also are good buyers. The price position is unaltered. Offers of Derbyshire, Staffordshire and Lancashire brands of No. 3 foundry iron equal to Derbyshire are all on the basis of 74s. per ton for delivery to Lancashire works, Northamptonshire at 72s. 6d., Scottish iron at 81s. 6d. to 82s. 6d., West Coast hematite at about 78s. 6d., and East Coast hematite at from 75s. to 76s. per ton, according to quality.

MIDLANDS.—The improvement in the foundry-iron trade in this area is maintained. Ironfounders who, a few weeks ago, were reducing their tonnages are now taking larger quantities, and it is anticipated that, so far as deliveries to consuming works are concerned, May will prove to have been a better month than any of its predecessors this year. Most consumers are covered ahead, so that there is little new booking at the moment, but there should be more activity in this direction shortly, as many contracts lapsed at the end of June. Activity in the light-castings trade is well maintained. The minimum zone prices continue to be quoted, the controlled rates, delivered Birmingham and Black Country stations, being 67s. 6d. per ton for Northants No. 3 and 71s. for Derbyshire, Lincolnshire and North Staffordshire No. 3, less a graduated rebate to large consumers. Forge pig-iron remains at 5s. per ton below these prices. Special irons are quoted as follow :—Medium-phosphorus grades, 72s. to 80s.; low-phosphorus, 85s. to 90s.; special refined irons, £5 7s. 6d. to £7 per ton, delivered. The controlled prices delivered this area for No. 3 hematite are 84s. 6d. for West Coast and 78s. for East Coast and Welsh hematite.

SCOTLAND.—Conditions in Scotland show little change from week to week. Activity in the Falkirk light-castings industry is very well maintained, and the foundries are using large quantities of Cleveland No. 3 iron, for which they are paying 67s. 3d. f.o.t. Falkirk. The quotation f.o.t. Glasgow is 70s. 3d., with other English foundry irons at 1s. 3d. per ton less. The official minimum for Scottish No. 3 foundry is 70s. f.o.t. furnaces, and for No. 1 72s. 6d. Users of Scottish iron are not buying ahead, preferring to cover their requirements as they arise.

Coke

Foundry coke is not a particularly active market at the moment, consumers being inclined to hold off in the hope of getting better prices, on the assumption that the coke makers will be experiencing a reduced demand during the summer months. Durham foundry coke is quoted at around 19s. to 22s. f.o.t. at ovens, and furnace coke at 16s. 6d. to 17s. 9d. For delivery in the Birmingham and Black Country area, best Durham foundry coke is quoted at 36s. to 40s., and Welsh from 34s. to 43s. 6d., according to analysis.

Steel

The recent improvement in the steel markets has been well maintained, and most departments of the industry have benefited materially from the restriction of Continental imports, says the official report of the London Iron and Steel Exchange. It is now known that the orders in the hands of the Continental Steel Cartel are sufficient to fill the entire quota of Continental steel until August 7, when the temporary arrangement expires. As a result, no fresh sales of steel by the industries in the Continental Steel Cartel are being made. The demand for semi-finished materials has sharply increased during the past few days as a result of the scarcity of Continental steel, although some imports are still reaching this country from the Continent against old contracts. The producers in this department are well sold forward, and considerable tonnages are being delivered to consumers. Business in finished steel materials has been active. The producing works are well employed and there is an active inquiry. The demand from overseas continues unsatisfactory, largely owing to the many restrictions in force in foreign markets.

Scrap

Firm conditions continue to rule in the scrap markets. There is a fairly steady demand in the Middlesbrough district for foundry cast iron, consumers paying 52s. 6d. to 53s. per ton delivered. Clean, light cast iron also has a good market at 44s. 6d. to 45s. In South Wales, heavy cast iron has a better sale and is firm at 52s. to 53s. Light cast-iron scrap is not offered in large quantities in South Wales, but a moderate business is being done in small lots at 43s. to 44s. Good cast-iron machinery scrap in sizes suitable for foundry use is quiet at 52s. 6d. to 55s. Scrap merchants in the Midlands continue to experience a good demand for cast-iron scrap at firm prices. Heavy machinery metal in handy sizes is offered at 55s. to 57s. 6d., good heavy metal at 50s., and clean light at 47s. 6d. Clean cast-iron borings are at 30s., delivered. In Scotland, also, some good parcels of cast-iron scrap have been disposed of at better prices. First-class heavy machinery cast-iron scrap is not too plentiful, and consumers are now paying up to 57s. 6d. per ton for this, with ordinary cast-iron scrap, suitable for foundries, and in pieces not exceeding 1 cwt., about 5s. less. Prices of scrap material in the Lancashire area are well held, good machinery metal being quoted at 52s. 6d. to 57s. 6d., delivered.

Metals

Copper.—The rise in copper prices was stayed on Wednesday, when a relapse was seen, mainly due to the uncertainties of the international situation, and spreading to the other base metals. Consumption is on a good scale, and stocks have been further reduced, so that a renewal of the recent firm conditions is expected.

Daily market prices :—

Cash.—Thursday, £34 2s. 6d. to £34 3s. 9d.; Friday, £34 8s. 9d. to £34 10s.; Monday, £34 16s. 3d. to £34 17s. 6d.; Tuesday, £34 5s. to £34 6s. 3d.; Wednesday, £32 7s. 6d. to £32 10s.

Three Months. — Thursday, £34 10s. to £34 11s. 3d.; Friday, £34 16s. 3d. to £34 17s. 6d.; Monday, £35 2s. 6d. to £35 3s. 9d.; Tuesday, £34 12s. 6d. to £34 13s. 9d.; Wednesday, £32 16s. 3d. to £32 17s. 6d.

Tin.—Prices, in common with other metals, have shown an easier tendency during the week. A further slowing down of buying activity for actual consumption is anticipated in some quarters.

In their review of the market Messrs. Rudolf Wolff & Company state :—"The restriction scheme and the existence of the buffer pool continue to meet with opposition, not only from operators on our market, but from producers, especially in Malaya. There is no doubt that the amount of tin available in the United Kingdom is small and, unless the buffer pool interests are going to help the market, the "squeeze" is not likely to be relieved. The statistical position is improving and it is estimated that there will be a reduction in the visible supply of about 1,000 tons at the end of this month. Consumptive demand is still good in America, but unless more tin is released under the quotas, we cannot look for any break in prices. The short account which existed seems to have been mostly covered and it would appear that a speculative bull account is being built up. If, on June 12, it is decided to increase the quotas, there will doubtless be freer offerings of tin by recent purchasers, and the difficulties which were experienced in the early days of March in selling tin may recur. We do not, however, think that any large bull account exists, but more speculative interest is being taken in this metal."

Messrs. Henry Gardner & Company, Limited, state: "The buffer pool is doing nothing to ease the present tightness of the near position, and hence the stringency remains. Consumers' demands to-day are chiefly for near material and consequently the market looks as if it may advance further."

Day-to-day fluctuations :—

Cash.—Thursday, £231 15s. to £232 5s.; Friday, £231 10s. to £231 15s.; Monday, £230 10s. to £230 15s.; Tuesday, £230 5s. to £230 12s. 6d.; Wednesday, £228 15s. to £229 5s.

Three Months.—Thursday, £224 5s. to £224 10s.; Friday, £223 15s. to £224 5s.; Monday, £222 10s. to £222 15s.; Tuesday, £223 to £223 5s.; Wednesday, £220 10s. to £220 15s.

Spelter.—Prices of spelter continued to rise until Tuesday of this week, when a setback occurred, owing to selling by holders who took an unfavourable view of international affairs, particularly in France and America. There is no scarcity of metal, although spot buying was not easy until quite recently.

Official quotations were as follow :—

Ordinary.—Thursday, £15 1s. 3d.; Friday, £15 2s. 6d.; Monday, £15 6s. 3d.; Tuesday, £15; Wednesday, £14 10s.

Lead.—With other metals, lead, which had previously maintained a firm tone, was affected by liquidations in mid-week. However, a setback was about due following the steady advance in recent weeks. The position is still quite good. A heavy demand continues from consumers in this country, and consumption on the Continent also is on a good scale.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £14 11s. 3d.; Friday, £14 11s. 3d.; Monday, £14 13s. 9d.; Tuesday, £14 7s. 6d.; Wednesday, £13 13s. 9d.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Willenhall Pressure Die Casting Company, Limited, Wolverhampton Road, Willenhall.—Capital, £1,000. Directors: G. T. Pitt and T. O. Reynolds.

Alfred Shirley, Limited, 81 and 83, Clifford Street, Lozells, Birmingham.—Capital, £2,000. General brassfounders. Directors: W. A. Willetts and A. B. Willetts.

MESSRS. HARLAND & WOLFF, LIMITED, have received an order from the Standard Fruit & Steamship Company, New Orleans, for a fruit and passenger-carrying steamer of 6,000 tons.

the basis of good cupola ganister....

Cupola operators, who take pride in the repair of their furnace linings, are justified in demanding a true ganister, made of hard Sheffield ganister rock and specially selected plastic fireclay, blended by craftsmen who understand their work.

SHEFFIELD GANISTER ROCK

Scene in a ganister mine

GENERAL REFRACTORIES LIMITED

Telephones:
Sheffield 22311 (5 lines)
London 7361 Temple Bar

Head Office:
Genefax House, Sheffield

London Office:
Russell House, Adelphi, W.C.2

Telegrams:
Genefax, Sheffield
Genefax, Rand, London

RAW MATERIALS—PRICE LIST

(Wednesday, May 29, 1935)

COPPER

	£ s. d.
Standard cash	32 7 6
Three months	32 16 3
Electrolytic	36 10 0
Tough	34 10 0
Best selected	35 0 0
Sheets	64 0 0
India	47 0 0
Wire bars	38 5 0
Ingot bars	38 5 0
H.C. wire rods	41 15 0
Off. av. cash, April	31 5 4⅞
Do., 3 mths., April	31 13 9
Do., Sttlmnt., April	31 5 3
Do., Electro, April	35 1 10½
Do., B.S., April	34 13 0⅜
Do., wire bars, April	35 8 6
Solid drawn tubes	10d.
Brazed tubes	10d.
Wire	6½d.

BRASS

Solid drawn tubes	9¼d
Brazed tubes	11¼d.
Rods, drawn	8½d.
Rods, extd. or rlld.	4½d.
Sheets to 10 w.g.	7¾d.
Wire	7⅝d.
Rolled metal	7¼d.
Yellow metal rods	4½d.
Do. 4 × 4 Squares	5¾d.
Do. 4 × 3 Sheets	5¾d.

TIN

	£ s. d.
Standard cash	228 15 0
Three months	220 10 0
English	229 5 0
Bars	231 0 0
Straits (nom.)	238 15 0
Australian (nom.)	—
Eastern	231 15 0
Banca	236 15 0
Off. av. cash, April	223 13 8¼
Do., 3 mths., April	219 18 0¾
Do., Sttlmt., April	223 13 9

SPELTER

	£ s. d.
Ordinary	14 10 0
Remelted	14 10 0
Hard	11 10 0
Electro 99.9	17 0 0
English	15 15 0
India	13 10 0
Zinc dust	17 10 0
Zinc ashes	3 5 0
Off. aver., April	13 0 2¼
Aver. spot, April	12 17 9¾

LEAD

	£ s. d.
Soft foreign ppt.	13 13 9
Empire (nom.)	15 0 0
English	15 15 0
Off. average, April	12 6 10⅞
Average spot, April	12 4 7½

ALUMINIUM

Ingots	£100 to £105
Wire	1/1 to 1/9 lb.
Sheet and foil	1/2 to 2/9 lb.

ZINC SHEETS, &c.

	£ s. d.
Zinc sheets, English	24 2 6
Do., V.M. ex-whse.	25 0 0
Rods	29 0 0

ANTIMONY

	£ s. d.
English	76 0 0 to 77 0 0
Chinese, ex-whse. (nom.)	64 0 0
Crude, c.i.f.	26 0 0

QUICKSILVER

	£ s. d.
Quicksilver	11 5 0 to 11 15 0

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	8 17 6
45/50%	12 15 0
75%	17 17 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/6 lb. Mo.
Ferro-titanium—	
23/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£15 15 0
Ferro-tungsten—	
80/85%	3/- lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	31 10 0
4/6% car.	21 15 0
6/8% car.	21 10 0
8/10% car.	21 10 0
Ferro-chrome—	
Max. 2% car.	34 0 0
Max. 1% car.	36 5 0
Max. 0.70% car.	37 5 0
70%, carbon-free	9¾d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	5/6 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to £11 5 0
76/80% packed	£11 15 0 to £12 5 0
76/80% export	(nom.) £9 15 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d
Finished bars, 18% tungsten	2s. 9d

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ⅛ in. to ¼ in.	3d. lb.
Do., under ¼ in. to $\frac{3}{16}$ in.	1/- lb.
Flats, ½ in. × ⅛ in. to under 1 in. × ⅜ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

South Wales—	£ s. d.	£ s. d.
Heavy steel	2 15 0	to 2 16 0
Bundled shrngs.		2 7 6
Mixed iron and steel	2 10 0	to 2 12 0
Heavy cast iron	2 12 0	to 2 13 0
Good machinery	2 12 6	to 2 15 0
Cleveland—		
Heavy steel		2 12 6
Steel turnings		1 15 0
Cast-iron borings		1 5 0
Heavy cast iron	2 12 6	to 2 13 0
Heavy machinery		2 15 0
Midlands—		
Light cast-iron scrap		2 7 6
Heavy wrought iron	2 17 6	to 3 0 0
Steel turnings		1 14 0
Scotland—		
Heavy steel		2 10 0
Ordinary cast iron		2 12 6
Engineers' turnings		1 19 6
Cast-iron borings	1 17 6	to 1 19 6
Wr'ght-iron piling	2 16 3	to 2 17 6
Heavy machinery		2 17 6

London—Merchants' buying prices, delivered yard.

	£ s. d.
Copper (clean)	29 0 0
Brass	20 0 0
Lead (less usual draft)	13 10 0
Tea lead	10 5 0
Zinc	9 0 0
New aluminium cuttings	66 0 0
Braziery copper	26 0 0
Gunmetal	26 0 0
Hollow pewter	165 0 0
Shaped black pewter	120 0 0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	70/-
Foundry No. 3	67/6
,, at Falkirk	67/3
,, at Glasgow	70/3
Foundry No. 4	66/6
Forge No. 4	66/6
Hematite No. 1	69/-
Hematite M/Nos.	68/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	72/6
,, d/d Birm.	84/6
Malleable iron d/d Birm.	115/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	67/-
,, No. 3 fdry.	71/-
Northants forge	63/6
,, fdry. No. 3	67/6
,, fdry. No. 1	70/6
Derbyshire forge	67/-
,, fdry. No. 3	71/-
,, fdry. No. 1	74/-
Scotland—	
Foundry No. 1, f.o.t.	72/6
,, No. 3, f.o.t.	70/-
Hem. M/Nos. d/d	71/-
Sheffield (d/d district)—	
Derby forge	64/6
,, fdry. No. 3	68/6
Lincs forge	64/6
,, fdry. No. 3	68/6
E.C. hematite	81/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	74/-
Staffs fdry. No. 3	74/-
Northants fdry. No. 3	72/6
Cleveland fdry. No. 3	74/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	82/6
Clyde, No. 3	82/6
Monkland, No. 3	82/6
Summerlee, No. 3	82/6
Eglinton, No. 3	82/6
Gartsherrie, No. 3	82/6
Shotts, No. 3	82/6

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.)	9 12 6	to 9 15 0
Nut and bolt iron	7 10 0	to 8 0 0
Hoops	10 10 0	and up.
Marked bars (Staffs)	f.o.t. 12 0 0	
Gas strip	10 10 0	and up.
Bolts and nuts, ¾ in. × 4 in.	14 2 6	and up.
Steel—		
Plates, ship, etc.	8 15 0	to 8 17 6
Boiler plts.	9 5 0	to 9 7 6
Chequer plts.	10 7 6	
Angles	8 7 6	
Tees	9 7 6	
Joists	8 15 0	
Rounds and squares, 3 in. to 5½ in.	9 7 6	
Rounds under 3 in. to ⅜ in. (Untested)	8 12 0	
Flats—8 in. wide and over	8 12 6	
,, under 8 in. and over 5 in.	8 17 6	
Rails, heavy	8 5 0	to 8 10 0
Fishplates	12 5 0	to 12 10 0
Hoops (Staffs)	9 7 0	
Black sheets, 24g. (4-t. lots)	10 10 0	
Galv. cor. shts. (,,)	13 0 0	
Galv. flat shts. (,,)	13 10 0	
Galv. fencing wire, 8g. plain	14 10 0	
Billets, soft	5 10 0	and up.
Billets, hard	6 17 6	to 7 2 6
Sheet bars	5 2 6	to 5 10 0
Tin bars	5 2 6	to 5 7 6

PHOSPHOR BRONZE

	Per lb. basis,
Strip	10d.
Sheet to 10 w.g.	11¼d.
Wire	12½d.
Rods	11d.
Tubes	13½d.
Castings	12d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1¼ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	20.31
No. 2 foundry, Valley	18.50
No. 2 foundry, Birm.	14.50
Basic, Valley	18.00
Bessemer	20.8832
Malleable, Valley	18.50
Grey forge, Valley	18.00
Ferro-mang. 80%, seaboard	85.00
O.-h. rails, h'y, at mill	36.37½
Billets	27.00
Sheet bars	28.00
Wire rods	38.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	1.80
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.70
Steel hoops	2.10
Sheets, black, No. 24	2.40
Sheets, galv., No. 24	3.10
Wire nails	2.60
Plain wire	2.30
Barbed wire, galv.	3.00
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	25/- to 30/-
,, furnace	19/- to 20/-
Durham foundry	19/- to 22/-
,, furnace	16/6 to 17/9
Scotland, foundry	28/-
,, furnace	25/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	18/2 to 19/2
,,	28×20 ,,	36/4 to 38/4
,,	20×10 ,,	26/-
,,	18¾×14 ,,	18/9
C.W.	20×14 ,,	15/3 to 15/6
,,	28×20 ,,	32/6 to 33/-
,,	20×10 ,,	23/- to 23/3
,,	18¾×14 ,,	15/6 to 15/9

SWEDISH CHARCOAL IRON & STEEL

	£ s. d.	£ s. d.
Pig-iron	£6 0 0	to £7 0 0
Bars-hammered, basis	£16 0 0	to £16 10 0
Bars and nail-rods, rolled, basis	£15 15 0	to £16 0 0
Blooms	£10 0 0	to £12 0 0
Keg steel	£30 0 0	to £31 0 0
Faggot steel	£18 0 0	to £23 0 0
Bars and rods dead soft, st'l	£10 0 0	to £12 0 0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£ s. d.	
May 23 ..	34 2 6 inc.	3/9
„ 24 ..	34 8 9 „	6/3
„ 27 ..	34 16 3 „	7/6
„ 28 ..	34 5 0 dec.	11/3
„ 29 ..	32 7 6 „	37/6

Electrolytic Copper

	£ s. d.	
May 23 ..	37 12 6 inc.	12/6
„ 24 ..	37 15 0 „	2/6
„ 27 ..	38 0 0 „	5/-
„ 28 ..	37 15 0 dec.	5/-
„ 29 ..	36 10 0 „	25/-

Standard Tin (cash)

	£ s. d.		
May 23 ..	231 15 0 inc.	50/-	
„ 24 ..	231 10 0 dec.	5/-	
„ 27 ..	230 10 0 „	20/-	
„ 28 ..	230 5 0 „	5/-	
„ 29 ..	228 15 0 „	30/-	

Tin (English ingots)

	£ s. d.		
May 23 ..	232 5 0 inc.	50/-	
„ 24 ..	231 15 0 dec.	10/-	
„ 27 ..	230 15 0 „	20/-	
„ 28 ..	230 15 0 No	change	
„ 29 ..	229 5 0 „	30/-	

Spelter (ordinary)

	£ s. d.		
May 23 ..	15 1 3 inc.	5/-	
„ 24 ..	15 2 6 „	1/3	
„ 27 ..	15 6 3 „	3/9	
„ 28 ..	15 0 0 dec.	6/3	
„ 29 ..	14 10 0 „	10/-	

Spelter (Electro, 99.9 per cent.)

	£ s. d.		
May 23 ..	17 11 3 inc.	2/6	
„ 24 ..	17 12 6 „	1/3	
„ 27 ..	17 16 3 „	3/9	
„ 28 ..	17 10 0 dec.	6/3	
„ 29 ..	17 0 0 „	10/-	

Zinc Sheets (English)

	£ s. d.	
May 23 ..	24 2 6 dec.	7/6
„ 24 ..	24 2 6 No	change
„ 27 ..	24 5 0 inc.	2/6
„ 28 ..	24 2 6 dec.	2/6
„ 29 ..	24 2 6 No	change

Lead (English)

	£ s. d.	
May 23 ..	16 10 0 No	change
„ 24 ..	16 10 0 „	„
„ 27 ..	16 10 0 „	„
„ 28 ..	16 10 0 „	„
„ 29 ..	15 15 0 dec.	15/-

AVERAGE MONTHLY PRICES OF FURNACE COKE D/D MIDDLESBROUGH

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1903	0 15 9	0 16 0	0 16 3	0 16 9	0 16 6	0 16 3	0 16 0	0 15 9	0 15 6	0 15 0	0 14 6	0 14 0	0 15 8½
1904	0 13 9	0 13 9	0 13 3	0 14 3	0 14 6	0 14 3	0 14 3	0 14 3	0 14 3	0 14 0	0 14 0	0 14 6	0 14 1½
1905	0 14 9	0 15 3	0 15 3	0 15 3	0 15 6	0 15 6	0 15 6	0 15 6	0 15 6	0 15 6	0 15 9	0 17 0	0 15 5½
1906	0 17 6	0 17 6	0 17 0	0 17 0	0 17 0	0 16 6	0 17 0	0 17 0	0 18 3	0 18 6	0 19 0	1 0 0	0 17 8½
1907	1 4 6	1 5 0	1 5 0	1 0 6	1 2 0	1 1 0	1 1 0	1 1 0	1 2 0	1 1 6	1 0 0	0 17 0	1 1 8½
1908	0 16 0	0 16 0	0 15 6	0 16 0	0 16 3	0 16 0	0 15 6	0 15 6	0 15 6	0 15 3	0 16 0	0 16 0	0 15 9½
1909	0 16 0	0 15 3	0 15 0	0 14 9	0 15 6	0 15 9	0 15 6	0 15 6	0 16 6	0 17 0	0 17 6	0 17 0	0 15 11½
1910	0 18 4½	0 18 6½	0 18 0	0 18 0	0 17 10½	0 17 0	0 16 1½	0 15 9½	0 15 11	0 16 0	0 15 9½	0 15 8	0 16 11
1911	0 16 0	0 15 10½	0 15 6	0 15 3	0 14 9	0 14 6	0 14 6	0 14 6	0 14 6	0 14 11½	0 15 0½	0 16 3½	0 15 1½
1912	0 17 3	0 17 3	0 18 6	0 18 10	0 19 0	0 19 4½	0 19 10½	1 0 9½	1 2 9	1 4 1½	1 5 8½	1 8 6	1 1 0
1913	1 5 9	1 4 11	1 5 0	1 5 0	1 4 9½	1 0 4½	0 19 5½	0 18 3	0 18 0	0 18 2½	0 18 6	0 18 6	1 1 4½
1914	0 18 2	0 17 1	0 17 0	0 17 0	0 17 4	0 17 6	0 17 6	0 18 5	0 18 4	0 17 9	0 17 6	0 18 5	0 17 8
1915	0 17 10½	0 17 9	1 0 4½	1 7 7½	1 9 4½	1 10 7½	1 9 7	1 7 3	1 5 4	1 4 9	1 9 6	1 13 0	1 6 1
1916	1 10 9	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6½
1917	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 14 3	1 15 6	1 11 2½
1918	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6
1919	1 15 6	1 15 6	1 15 6	1 15 6	2 1 6	2 1 6	2 3 9	2 10 6	2 10 6	2 10 6	2 10 6	2 10 6	2 3 5
1920	2 12 3	2 14 0	2 19 0	2 19 0	3 3 8	3 6 0	3 6 0	3 6 0	3 6 0	3 6 0	3 6 0	3 6 0	3 2 6
1921	3 1 0½	2 19 0	2 16 0	2 7 0	2 6 6	2 6 6	2 0 6	2 0 0	1 13 11	1 12 9	1 10 4½	1 8 3	2 3 6½
1922	1 7 0½	1 8 1½	1 9 7½	1 8 4½	1 7 11½	1 7 3	1 6 9½	1 6 10½	1 7 0½	1 10 2½	1 10 0	1 9 11½	1 8 3½
1923	1 11 3	1 14 6	2 0 1½	2 2 8½	2 4 4½	2 2 10½	2 1 0½	2 1 6	2 0 9½	1 18 9	1 18 8½	1 18 3	1 19 7½
1924	1 16 6½	1 14 9	1 11 11½	1 10 0½	1 8 1½	1 7 8½	1 7 3	1 6 3	1 6 0	1 5 0	1 5 0	1 5 0	1 9 5½
1925	1 4 10½	1 4 1½	1 13 3	1 2 4½	1 2 2½	1 1 5½	1 1 3½	1 4 9	0 18 10½	0 18 4½	0 19 6½	1 1 4½	1 2 8½
1926	1 2 1½	1 0 9	0 19 2½	0 18 6½	*	*	*	*	*	*	*	1 5 0	1 1 1‖
1927	1 5 6	1 4 9½	1 6 1½	1 3 9	1 2 6	1 0 8½	0 19 4½	0 19 0	0 18 7½	0 18 0	0 17 10½	0 17 6	1 1 1½
1928	0 17 6	0 17 10½	0 18 0½	0 17 11½	0 17 8½	0 17 6½	0 17 7½	0 17 6	0 17 6	0 17 7½	0 17 7½	0 17 6	0 17 8
1929	0 17 7½	0 18 0	0 19 0	0 19 6½	0 18 10½	0 19 10½	1 1 3½	1 1 8½	1 3 0	1 3 6	1 3 8	1 3 1½	1 0 9½
1930	1 2 6½	1 1 3	1 0 3	0 19 1½	0 17 7	0 16 10½	0 16 6	0 16 6	0 16 9	0 17 0	0 17 0	0 17 0	0 18 2½
1931	0 17 0	0 16 7½	0 16 0	0 16 0	0 15 11	0 15 5	0 15 1	0 15 0	0 15 0	0 16 9	0 17 0	0 16 6	0 16 0½
1932	0 17 0	0 16 11½	0 16 5½	0 15 9	0 15 7½	0 15 6	0 15 6	0 14 9½	0 14 6½	0 14 6	0 14 6	0 15 4	0 15 6½
1933	0 16 0½	0 15 11½	0 15 6½	0 15 6	0 15 6	0 15 6	0 15 6	0 15 8½	0 16 1½	0 17 0	0 17 6	0 18 0	0 16 1½
1934	0 19 1½	1 0 6	1 0 2	1 0 0	1 0 0	1 0 0	1 0 0	1 0 0	1 0 0	1 0 0	1 0 0	1 0 0	0 19 11½
1935	1 0 0	0 19 6½	0 19 0½	0 19 0	0 19 0	—	—	—	—	—	—	—	—

* Strike period. ‖ Five months.

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

CLARENCE CHAMBERS, 39, CORPORATION STREET, BIRMINGHAM.

13, RUMFORD STREET, LIVERPOOL.

PIG IRON

REGISTERED TRADE MARK

LIMPET

All grades FOUNDRY, HEMATITE, BASIC, SPECIALS, &c.

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM JACKS & COMPANY,

CENTRAL CHAMBERS, 93, HOPE ST., GLASGOW, C.2.

ZETLAND ROAD, MIDDLESBROUGH.

XUM

Notice

Small Advertisements in this section of the Journal are accepted at the prepaid rate of 6d. per line, first line in capitals counting two, average 6 words per line. Minimum charge for one insertion 3/-

(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED

FOREMAN or Assistant Foreman. Position required. Experienced general engineering castings up to 30 tons. British and American experience. Technically trained.—Box 250, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRY MANAGER or Foreman seeks position with progressive firm; 14 years' experience general engineering castings, quantity production; good organiser; disciplinarian.—Box 266, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

IRONFOUNDRY Foreman working in Lancashire town seeks position with progressive firm; 36 years' experience in modern foundry practice.—Box 248, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

QUALIFIED Metallurgist wanted for works near London, producing I.C. engine components. Practical knowledge of alloying in cast iron, steel and aluminium most desirable, with ability to control foundry production.—Apply Box 268, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

A FOUNDRYMAN of good address, and one who has had actual responsibility of shop management, is required to take charge of large, modern quantity-production foundry in the Midlands. Apply stating age, qualifications, experience and salary required to Box 262, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRY FOREMAN required, age about 40, for South Manchester foundry engaged in high-class light and heavy castings up to 30 tons. Candidates must be experienced moulders with previous supervision and executive experience. Some technical training would be an advantage. Apply with full particulars of experience and state when at liberty.—Box 270, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRY MANAGER required (London job); age not to exceed 35. Must be sound, practical man capable of organising production and with extensive knowledge of production of piston castings in Y alloy—sand core—metal chills. Write giving full particulars of career and remuneration required.—Box 264, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

SMALL-MEDIUM Steel Foundry requires capable Works Manager, or General Manager might suit if applicant has experience of foundry work. Particulars and salary.—Box 272, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

EMPLOYMENT REGISTER.

Conducted by the Institute of British Foundrymen by courtesy of the proprietors of THE FOUNDRY TRADE JOURNAL.

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

Any employer wishing to communicate with a candidate should write to the General Secretary, quoting identification number.

PRACTICAL Foundryman with sound experience of mixing of aluminium and special alloys desires position. (260)

MACHINERY

MORGAN TILTING FURNACES for sale; sizes 400, 600 and 800 lbs. capacity; several in stock, oil-fired, also coke-fired. Please state requirements. Cheap prices; immediate delivery; relined ready for use.—ALEX. HAMMOND, 14, Australia Road, Slough.

SAND MIXERS AND MILLS for sale, several well-known makes in stock. Write stating requirements.—Box 260, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

SAND PLANT.

ROTOIL No. 4 oilsand mixer. Ketin & Thiviart three-in-one motor-driven sand-mill, mixer and whizzer. Pneulec large oilsand mixer. Several pneumatic sand sifters.—ALEX. HAMMOND, Foundry Machinery Merchant, 14, Australia Road, Slough.

NEW Dwarf Cupola, to melt 10 to 15 cwts. per hr. New Worm-geared Ladles, 5 tons, 25 cwts., 15 cwts. and 10 cwts. capacity. Ungeared Ladles, 15 cwts. and 10 cwts. capacity. Improved Cupola Spark Arresters.—T. DAVIES & SON, West Gorton, Manchester.

TILGHMAN SAND BLAST ROOM for sale, 12 ft. by 9 ft., standard-type plant, practically new, owing to centralisation. This plant can be seen erected and will be sold reasonably owing to the closing of a large works, in London.—Box 252, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

SANDBLAST PLANTS

Room Plants, sizes 12 ft. x 12 ft., 12 ft. x 9 ft. and 6 ft. x 6 ft., made up in cast-iron sections.

Barrel Plants, 30 in. dia. x 36 in. long and 30 in. dia. x 18 in. long rotary barrels.

Cabinet Plants, in sizes 4 ft. x 4 ft. x 4 ft., 36-in. dia. and 30-in. dia. operators' cabinets.

Most of the above by Tilghman and complete with Air Compressors.

HAND MOULDING MACHINES

By Adaptable, Pridmore, Darling & Sellars, etc.; Squeezers by Utard (unused), Samuelson and Britannia, also Farwell Universal Type.

Ladles, Grinding Machines, Exhaust Fans, Blowers, Air Compressors and 500 Electric Motors and Dynamos.

S. C. BILSBY, A.M.I.C.E., A.M.I.E.E.

CROSSWELLS ROAD (Adjoining Railway Crossing), LANGLEY, Nr. Birmingham.

'Phone: Broadwell 1359.

THOS. W. WARD LTD.

48" motor-driven ventilating FAN (Keith Blackman), 250 volts, 450 r.p.m., starter.

Vert. two-throw PUMP, 133 galls. p.m., 270' head, 12" dia. ram, 12" stroke, 8" dia. suc. and del.; driven through gearing; metal liners.

Two 16" Princeps "LITTLE SCORCHER" STEAM DRYERS.

FOR SALE OR HIRE—10 tons cap. main-line steel-framed TANK WAGON, standard gauge.

Write for "Albion" Catalogue.

Grams: "Forward." 'Phone: 23001 (10 lines).

ALBION WORKS, SHEFFIELD.

MISCELLANEOUS

GANISTER. Large deposits finely ground for sale at 14s. per ton f.o.r. station, Sheffield District; also Silica suitable for mixing purposes and useful in a variety of ways at 8s. 6d. per ton.—Write Box 258, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

MISCELLANEOUS—*Continued*

FLUIDITY TESTS as described in THE FOUNDRY TRADE JOURNAL, February 1, 1934. Patterns of the above in aluminium can be supplied for 35s. per set. Post free. We can also supply Patterns for all branches of the engineering trade, in hard or soft woods. Send us your inquiries. — FURMSTON & LAWLOR, Patternmakers, Letchworth, Herts.

'Phone: 287 SLOUGH

MOULDING MACHINES

406 OSBORN jolt rollover.
No. 4 BRITANNIA rollover jolter.
18"×36" TABOR rollover shockless (portable).
40"×30" TABOR rollover shockless.
TWO BRITANNIA No. 1 jolters.

SANDBLAST PLANTS

8'×8'×8' Tilghman room plant with 300 cu. ft. Tilghman compressor dry air filter and all equipment, practically new plant throughout.

12' × 9' Tilghman sandblast room, built of cast iron plates, complete with 400 cu. ft. Tilghman air compressor and all accessories. FINE PLANT.

T.B. 4 Tilghman sandblast barrel plant, complete. Size of barrel 60" × 40".

T.B. 1 Tilghman sandblast barrel 30"×20".

BUY FROM ME AND SAVE MONEY!

ALEX. HAMMOND, *Foundry Machinery Merchant,*
14, AUSTRALIA ROAD, SLOUGH

GANISTER

Purchase your supplies from actual Producers with over 50 years' reputation

Scientifically treated, specially ground Ganister for Cupolas, Iron & Steel Works, &c.

SPECIAL LADLE GANISTER

TRIAL BAGS FREE
Quotations on application

The ASTBURY SILICA CO.
CONGLETON, Cheshire
Est. 50 Years

SELECT YOUR MACHINE FROM THE LARGEST STOCK OF HIGH CLASS SECONDHAND MOULDING MACHINES IN THE WORLD

Practical Advice Free

THE COLEMAN FOUNDRY EQUIPMENT CO., LTD., 156, STRAND, LONDON, W.C.2.